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**GRAND RIVER BASIN  
WATER MANAGEMENT STUDY  
TECHNICAL REPORT SERIES**



**EXISTING AND FUTURE  
WATER DEMAND FOR  
THE GRAND RIVER BASIN  
TECHNICAL REPORT No. 26**

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GRAND RIVER BASIN WATER MANAGEMENT STUDY  
GRAND RIVER STUDY TEAM

TECHNICAL REPORT SERIES  
REPORT #26

EXISTING AND FUTURE WATER DEMAND FOR  
THE GRAND RIVER BASIN

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1983



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## ABSTRACT

This report is one of a series of technical documents prepared as part of the Grand River Basin Water Management Study for the Grand River Implementation Committee. It outlines existing and possible future water demand and identifies areas where future water shortages are probable.

Water demand is projected under four general categories: municipal, industrial, agricultural, and other (rural domestic, commercial and recreational). Projecting water demand is a challenging task because of the large number and variability of factors which may effect future change. Accordingly, a variety of analytical methods are used based on several scenarios for future urban and rural land use and population growth as outlined in Technical Report No. 8 Existing and Future Land Use Activities Within the Grand River Basin and Technical Report No. 12 Population Projections for Municipalities Within the Grand River Basin.

Water shortages are not expected in rural areas on the whole, although water storage for irrigating crops may be required in specific sub-basins if a drought extended over the summer months. In urban areas, water supply must be supplemented by new supplies in Kitchener, Waterloo, Cambridge and Guelph by the year 2001, if no conservation measures, or new pricing structures are implemented. The time at which new supplies would be required for these cities is dependent on population growth and water conservation practices. Two smaller communities, Fergus and Elora, may experience water shortages by the year 2031.

The information presented in this report provides a basis for the selection and timing of new supply projects. These projects form part of several overall water management plans investigated by the Basin Study and are outlined in associated technical reports. Questions with respect to this report should be directed to the Co-ordinator of the Grand River Basin Water Management Study, 400 Clyde Road, Box 729, Cambridge, Ontario.

## ACKNOWLEDGEMENTS

Special thanks are extended to the many people and agencies who contributed to this report, particularly the Ontario Ministry of the Environment, Canada Mortgage and Housing Corporation, and basin municipalities. Other members of the Study Team who contributed data used in the compilation of this report include Marlene Lloyd, Paul Frigon and Donald Veale.



## CONVERSTION FACTORS

1 acre = 0.4046856 hectares (ha)

1 inch = 25.4 millimetres (mm)

1 million gallons per day (mgd) = 4546 cubic metres per day ( $\text{m}^3/\text{d}$ )

1 gallon per day (gpd) = 4.546 litres per day (L/d)

1 gallon per capita per day (gpcd) = 4.546 litres per capita per day  
(L/capita·day)

1,000 gallons (gal) = 0.455 cubic metres ( $\text{m}^3$ )

## 1. INTRODUCTION

Extraction of surface and ground water for consumptive purposes within the Grand River basin can be classified under four general categories: municipal, industrial, agricultural, and other.

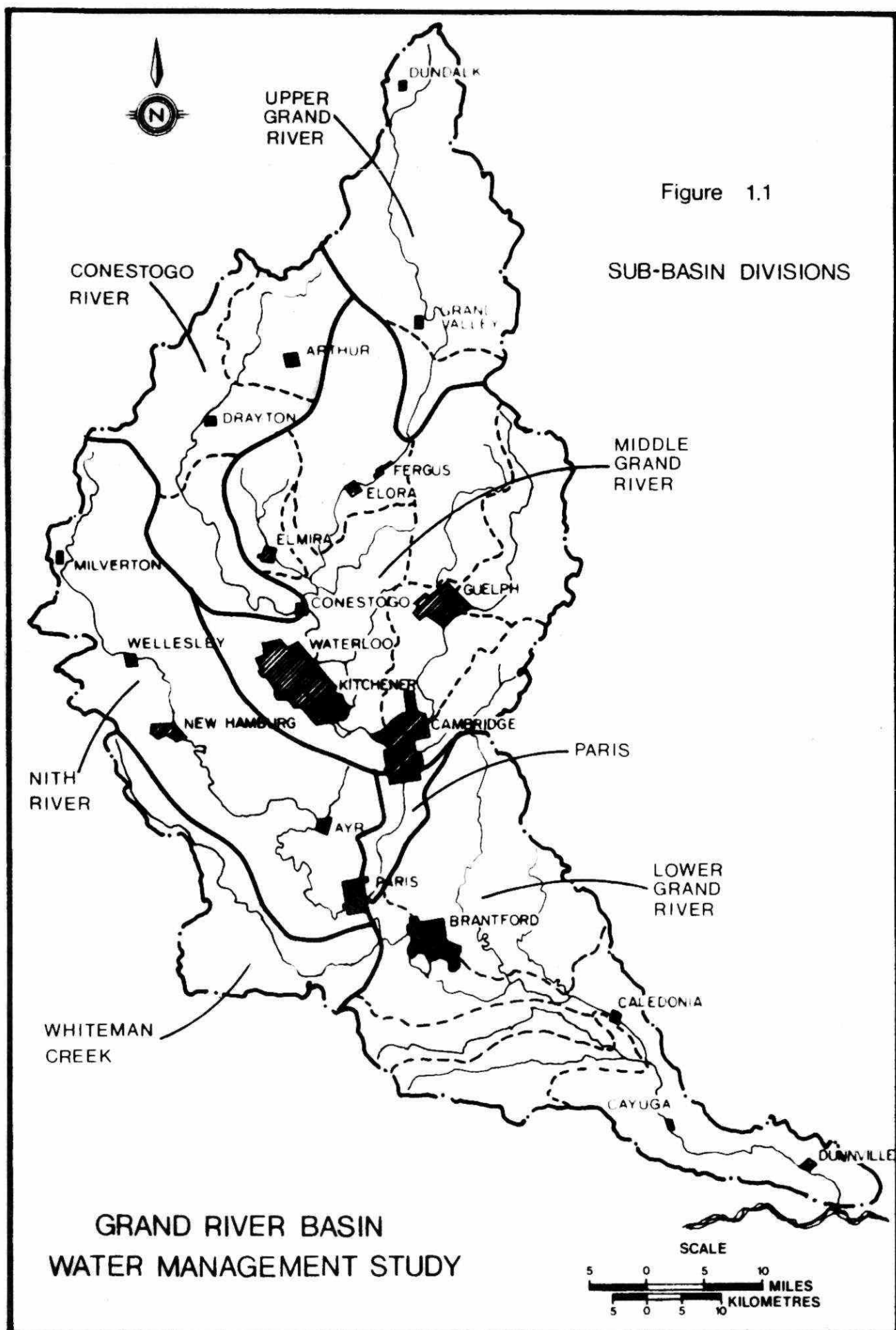
A municipal water supply system usually services residential, industrial, institutional, and commercial water consumers within an urban area, from a water distribution network linked to a common water source or sources. While most industries are linked to a municipal water supply system, there is a significant number of major industries particularly in the central basin, that obtain large quantities of water from private sources. Similarly, a significant amount of water is extracted from private sources for agricultural use such as irrigation and livestock consumption.

The "other" category refers to a limited number of commercial and recreational establishments which consume small quantities of water from private sources, usually on a seasonal basis.

The impact of water demand on available water resources in a particular area varies with the type of use and the extent of water sources. In the Grand River basin, the greatest stress is placed on water supplies in the central basin, particularly in the five major urban centres of Kitchener, Waterloo, Cambridge, Guelph and Brantford where water is consumed primarily for municipal and industrial uses.

Future growth in water demand within the basin may require additional water supplies in certain areas and will have a critical influence on the selection and timing of new supply projects. Hence, a detailed analysis of existing and possible future water demand was undertaken in order to identify areas where future water shortages are probable.

The succeeding chapters discuss existing and future water demand for the four categories identified above and indicate the location and extent of possible water shortages. Data are presented according to municipality and/or the sub-basin sectors outlined in Figure 1.1.



## 2. MUNICIPAL WATER DEMAND

### 2.1 EXISTING WATER USE

Water taking permit records, available for the Grand River basin from the Ontario Ministry of the Environment, provide an estimate of the amount of ground and surface water allocated for consumptive purposes to municipalities. In 1978, 52.846 million gallons of water per day (mgd) (240 215 cubic metres per day ( $m^3/d$ )) were authorized for municipal use (Appendix A). This figure closely approximates the sum of the average daily consumption for all communities within the basin on a municipal water supply system (Table 2.1).

Within the basin, ground water is the primary source for municipal water supplies. In 1979, 19 communities extracted ground water for municipal supplies while 4 communities completed ground-water surveys in anticipation of future ground-water supply systems (Burford, Drayton, Grand Valley and Salem). By contrast, only 3 communities utilized surface water sources for municipal supplies (Brantford, Cayuga and Dunnville). A summary of water use statistics for these communities is outlined in Table 2.1.

Statistics indicate that approximately 81% of the total population of the basin uses water supplied by municipal systems. The remaining population (approximately 105,000) is supplied by private water sources, primarily wells. Four cities: Kitchener, Waterloo, Cambridge, and Guelph place the most stress on ground water. Although the City of Brantford exhibits high consumption rates, little stress is placed on water supply since water is extracted directly from the Grand River.

Water consumption in the major urban centres by user class and by season is outlined in Table 2.2. Because of the extensive information base required, these data were collected for only one year, 1978 (Appendix B). In addition, further research was undertaken to describe the primary demographic and economic factors which influence municipal water demand: pricing systems for water sales (Table 2.3); employment characteristics (Table 2.4); and residential land use and demographic characteristics (Table 2.5).

TABLE 2.1  
Summary of Municipal Water Use Characteristics for the Grand River Basin

| Community   | Serviced<br>Population<br>1976 | Average Daily<br>Consumption (mgd)<br>1977 | Maximum Daily<br>Consumption (mgd)<br>1977 | Per Capita<br>Consumption (gpd) <sup>1</sup><br>1976-1977 | System<br>Capacity (mgd) <sup>2</sup><br>1979 | Source of<br>Water Supply <sup>2</sup><br>1979 |
|-------------|--------------------------------|--------------------------------------------|--------------------------------------------|-----------------------------------------------------------|-----------------------------------------------|------------------------------------------------|
| Arthur      | 1,628                          | 0.200                                      | 0.390                                      | 123                                                       | 0.633                                         | 6 wells                                        |
| Ayr         | 1,331                          | 0.110                                      | N/A                                        | 83                                                        | 1.037                                         | 2 wells                                        |
| Baden       | 4,300 }                        | 0.409 }                                    | 0.649 }                                    | 95 }                                                      | 1.382                                         | 2 wells                                        |
| New Hamburg |                                |                                            |                                            |                                                           | .302                                          | 2 wells                                        |
| Caledonia   | 3,774                          | 0.323                                      | 0.645                                      | 86                                                        | 2.560                                         | 5 wells                                        |
| Cambridge   | 72,950                         | 8.577                                      | 12.866                                     | 118                                                       | 16.990                                        | 25 wells                                       |
| Dundalk     | 1,130                          | 0.113                                      | 0.201                                      | 100                                                       | 0.432                                         | 3 wells                                        |
| Elmira      | 8,095 }                        | 1.680 }                                    | 2.810 }                                    | 208 }                                                     | 4.460                                         | 6 wells                                        |
| St. Jacobs  |                                |                                            |                                            |                                                           | 0.150                                         | 2 wells                                        |
| Elora       | 2,425                          | 0.247                                      | 0.355                                      | 102                                                       | 0.668                                         | 2 wells                                        |
| Fergus      | 5,967                          | 0.615                                      | 0.900                                      | 103                                                       | 1.764                                         | 5 wells                                        |
| Guelph      | 71,349                         | 9.500                                      | 13.100                                     | 133                                                       | 25.81 (winter)                                | 27 wells                                       |
|             |                                |                                            |                                            |                                                           | 28.81 (summer)                                | Arnell Springs                                 |
| Kitchener   | 133,815                        | 18.177 }                                   | 29.084 }                                   | 98 }                                                      | 22.242                                        | 29 wells                                       |
| Waterloo    | 51,473                         |                                            |                                            |                                                           | 8.774                                         | 12 wells                                       |
|             |                                |                                            |                                            |                                                           | 1.632                                         | 2 infiltration wells<br>(Kitchener-Waterloo)   |
| Maryhill    | 150                            | 0.008                                      | N/A                                        | 53                                                        | 0.072                                         | 2 wells                                        |
| Milverton   | 1,402                          | 0.129                                      | N/A                                        | 92                                                        | 0.315                                         | 2 wells                                        |
| Paris       | 6,993                          | 1.060                                      | 1.630                                      | 152                                                       | 2.880                                         | 2 wells                                        |
| Plattsville | N/A                            | N/A                                        | N/A                                        | N/A                                                       | 0.374                                         | 2 wells                                        |
| Rockwood    | N/A                            | N/A                                        | N/A                                        | 56                                                        | 0.864                                         | 2 wells                                        |
| St. George  | 1,000                          | 0.150                                      | 0.230                                      | 150                                                       | 1.800                                         | 1 well                                         |
| Brantford   | 69,091                         | 9.670                                      | 16.120                                     | 140                                                       | 17.500                                        | Grand River                                    |
| Cayuga      | 1,154                          | 0.150                                      | 0.240                                      | 130                                                       | 0.240                                         | Grand River                                    |
| Dunnville   | 5,553                          | N/A                                        | N/A                                        | N/A                                                       | 3.200                                         | Lake Erie                                      |

N/A - Not Available

<sup>1</sup>Note: Per capita consumption rates were estimated by dividing the 1976 serviced population into the 1977 average daily consumption rates.

<sup>2</sup>Source: Sibul, Walmsley and Szudy (1980).

TABLE 2.2

Water Consumption Characteristics for Major Urban Centres, 1978

| CITY                                       | WATERLOO  | KITCHENER | GUELPH    | BRANTFORD | CAMBRIDGE | AVERAGE |
|--------------------------------------------|-----------|-----------|-----------|-----------|-----------|---------|
| ANNUAL CONSUMPTION<br>BREAKDOWN (%)        |           |           |           |           |           |         |
| Residential                                | 31        | 26        | 25        | 26        | 27        | 26      |
| Industrial                                 | 20        | 36        | 25        | 40        | 26        | 30      |
| Apartment                                  | 10        | 12        | 9         | 6         | 7         | 9       |
| Institutional                              | 15        | 6         | 13        | 4         | 5         | 10      |
| Commercial                                 | 12        | 10        | 5         | 4         | 15        | 9       |
| Unaccounted                                | <u>12</u> | <u>10</u> | <u>23</u> | <u>20</u> | <u>20</u> | 19      |
| TOTAL                                      | 100       | 100       | 100       | 100       | 100       |         |
| TOTAL gpcd                                 | 99        | 103       | 131       | 143       | 115       | 119     |
| AVERAGE SUMMER DAY<br>÷ AVERAGE WINTER DAY | 1.12      | 1.17      | 1.15      | 1.28      | 1.12      | 1.17    |
| MAXIMUM DAY ÷<br>AVERAGE DAY               | 1.65      | 1.55      | 1.70      | 1.61      | 1.54      | 1.62    |
| RESIDENTIAL CON-<br>SUMPTION (gpd/METER)   |           |           |           |           |           |         |
| Average annual                             | 133       | 126       | 159       | 135       | 124       | 133     |
| Average winter                             | 122       | 106       | 118       | 81        | 112       | 105     |
| Average summer                             | 166       | 176       | 189       | 183       | 155       | 171     |
| Maximum day                                | 381       | 362       | 479       | 419       | 321       | 392     |

TABLE 2.3

## Water Rates for Major Urban Centres, 1978

| CITY                         | WATERLOO                   | KITCHENER                | GUELPH                      | CAMBRIDGE               | BRANTFORD                                                            |
|------------------------------|----------------------------|--------------------------|-----------------------------|-------------------------|----------------------------------------------------------------------|
| TYPE OF RATE STRUCTURE       | FLAT UNIT RATE             | DECLINING BLOCK          | DECLINING BLOCK             | DECLINING BLOCK         | DECLINING BLOCK                                                      |
| <u>Block 1</u>               |                            |                          |                             |                         |                                                                      |
| size (gal)<br>rate/1,000 gal | 0<br>\$.53                 | 0-3,115<br>\$.85         | 0-50,000<br>\$.55           | 0-75,000<br>\$.63       | 0-44,000<br>\$.55                                                    |
| <u>Block 2</u>               |                            |                          |                             |                         |                                                                      |
| size (gal)<br>rate/1,000 gal | N/A                        | 3,116-105,910<br>\$.71   | 50,001-300,000<br>\$.45     | >75,000<br>\$.51        | 44,001-374,000<br>\$.42                                              |
| <u>Block 3</u>               |                            |                          |                             |                         |                                                                      |
| size (gal)<br>rate/1,000 gal | N/A                        | 105,911-186,900<br>\$.64 | 300,001-12,000,000<br>\$.35 | N/A                     | >374,000<br>\$.33                                                    |
| <u>Block 4</u>               |                            |                          |                             |                         |                                                                      |
| size (gal)<br>rate/1,000 gal | N/A                        | >186,900<br>\$.59        | >12,000,000<br>\$.25        | N/A                     | N/A                                                                  |
| Sewer Surcharge              | 100% of consumption charge | 75% of total water bill  | 70% of total water bill     | 70% of total water bill | fixed rate for small meter, 85% of total water bill for large meters |

N/A - Not applicable

TABLE 2.4  
Industrial Profiles for Major Urban Centres, 1978

| CITY                                            | WATERLOO | KITCHENER | GUELPH | CAMBRIDGE | BRANTFORD |
|-------------------------------------------------|----------|-----------|--------|-----------|-----------|
| % OF POPULATION<br>WORKING IN INDUSTRY          | 16       | 20        | 16     | 28        | 26        |
|                                                 |          |           |        |           |           |
| % INDUSTRIAL EMPLOYEES<br>BY INDUSTRY TYPE      |          |           |        |           |           |
| Food and Beverage                               | 7        | 18        | 4      | 3         | 4         |
| Tobacco Products                                | --       | --        | 8      | --        | --        |
| Rubber and Elastic Products                     | 9        | 9         | 3      | 3         | 6         |
| Leather Products                                | 2        | 13        | --     | 7         | --        |
| Textiles                                        | 7        | 4         | 2      | 10        | 2         |
| Clothing                                        | 1        | 6         | 5      | 1         | 5         |
| Wood                                            | 5        | 1         | 1      | 1         | 2         |
| Furniture and Fixtures                          | 9        | 1         | 1      | 2         | 2         |
| Paper and Allied Products <sup>1</sup>          | 1        | 1         | 2      | --        | 5         |
| Printing and Publishing                         | 2        | 3         | 2      | 1         | 3         |
| Primary Metals <sup>1</sup>                     | 1        | 1         | 8      | 4         | 7         |
| Machinery                                       | 8        | 7         | 15     | 18        | 33        |
| Metal Fabricating                               | 13       | 10        | 12     | 20        | 8         |
| Transport Equipment                             | --       | 10        | 2      | 7         | 5         |
| Electrical Products                             | 37       | 8         | 25     | 11        | 8         |
| Non-metallic Mineral<br>Products                | --       | 2         | 2      | 1         | 6         |
| Chemicals and Chemical<br>Products <sup>1</sup> | 2        | 2         | 7      | 7         | 4         |
| Miscellaneous                                   | 1        | 1         | 1      | 2         | 3         |

<sup>1</sup>These industries are the largest water users.

Source: Williams and Veale (1980).



TABLE 2.5  
Demographic and Land Use Characteristics for Major Urban Centres

| CITY                                       | WATERLOO | KITCHENER | GUELPH | CAMBRIDGE | BRANTFORD |
|--------------------------------------------|----------|-----------|--------|-----------|-----------|
| Serviced Population <sup>1</sup>           | 51,473   | 133,815   | 71,349 | 69,091    | 72,950    |
| Total Serviced Dwelling Units <sup>1</sup> | 16,993   | 43,806    | 23,048 | 25,119    | 23,988    |
| Persons per Dwelling Unit <sup>1</sup>     | 3.03     | 3.05      | 2.10   | 2.75      | 3.04      |
| % Apartment Units <sup>2</sup>             | 34       | 34        | 30     | 24        | 21        |
| % Attached Units <sup>2</sup>              | 11       | 11        | 12     | 13        | 9         |
| % Semi-detached Units <sup>2</sup>         | 5        | 5         | 3      | 6         | 8         |
| % Detached Units <sup>2</sup>              | 51       | 51        | 55     | 57        | 61        |
| Residential Acreage <sup>3</sup><br>(1976) | 2,174    | 5,894     | 4,020  | 4,867     | 4,901     |

<sup>1</sup>Source: Appendix B, Table B1.1.

<sup>2</sup>Source: Canada Census, 1976 (catalogue 92-810).

<sup>3</sup>Source: Veale (1980 a).

## 2.2 FUTURE WATER DEMAND

The stress on ground-water supplies is expected to increase as urban growth continues. Table 2.6 outlines the projected low, medium and high populations for each municipality located wholly or partly within the basin (Technical Report No. 12; and Veale, 1980 b). An additional "low low" projection was generated for the Cities of Kitchener, Waterloo and Cambridge as follows:

| Projected Population |                |                |
|----------------------|----------------|----------------|
| "Low Low"            |                |                |
|                      | <u>2001</u>    | <u>2031</u>    |
| Kitchener            | 186,369        | 221,757        |
| Waterloo             | 69,838         | 83,060         |
| Cambridge            | <u>111,533</u> | <u>132,699</u> |
| Total                | 367,740        | 437,516        |

According to these estimates, the combined population of the Cities of Kitchener, Waterloo, Cambridge and Guelph could range between 458,000 and 587,500 by the year 2001, and 559,000 and 998,500 by the year 2031.

The following sections describe the methodologies used to predict water needs for basin municipalities and detail estimates of future municipal water demand. The implications of these analyses on water management are also discussed.

### 2.2.1 Major Urban Centres

Three basic approaches were used in projecting future municipal water demand for the Cities of Kitchener, Waterloo, Cambridge, Guelph and Brantford. Demand was predicted by assuming that: (1) existing water consumption rates remain the same in the future (base case projection), (2)

TABLE 2.6

## Population Projections by Municipality for the Grand River Watershed

| Municipality                           | Population<br>(1976) | Low<br>Projection<br>(2001) | Medium<br>Projection<br>(2001) | High<br>Projection<br>(2001) | Low<br>Projection<br>(2031) | Medium<br>Projection<br>(2031) | High<br>Projection<br>(2031) |
|----------------------------------------|----------------------|-----------------------------|--------------------------------|------------------------------|-----------------------------|--------------------------------|------------------------------|
| Halton Region                          | 2,381                | 2,697                       | 3,053                          | 3,906                        | 3,131                       | 4,115                          | 7,074                        |
| Town of Milton                         | 1,705                | 1,931                       | 2,186                          | 2,797                        | 2,243                       | 2,947                          | 5,066                        |
| Town of Halton Hills                   | 676                  | 766                         | 867                            | 1,109                        | 889                         | 1,168                          | 2,008                        |
| Haldimand-Norfolk Region               | 17,776               | 24,329                      | 27,514                         | 31,628                       | 33,074                      | 38,843                         | 45,975                       |
| Town of Haldimand                      | 8,961                | 13,596                      | 16,367                         | 19,739                       | 19,504                      | 23,494                         | 28,316                       |
| Caledonia                              | 3,669                | 6,500                       | 9,750                          | 13,000                       | 13,000                      | 15,825                         | 18,649                       |
| Cayuga                                 | 1,143                | 1,200                       | 1,850                          | 2,500                        | 2,500                       | 3,043                          | 3,586                        |
| Town of Dunnville                      | 5,969                | 7,815                       | 7,923                          | 8,458                        | 10,563                      | 11,580                         | 13,366                       |
| City of Nanticoke                      | 2,846                | 2,918                       | 3,224                          | 3,431                        | 3,007                       | 3,774                          | 4,293                        |
| Hamilton-Wentworth Region              | 11,279               | 11,993                      | 12,775                         | 14,420                       | 12,912                      | 14,788                         | 19,372                       |
| Town of Ancaster                       | 3,268                | 3,478                       | 3,701                          | 4,191                        | 3,749                       | 4,299                          | 5,649                        |
| Township of Flamborough                | 7,710                | 8,206                       | 8,734                          | 9,888                        | 8,845                       | 10,144                         | 13,327                       |
| Township of Glanbrook                  | 301                  | 309                         | 320                            | 341                          | 318                         | 345                            | 396                          |
| Waterloo Region                        | 291,164              | 459,900                     | 490,057                        | 509,942                      | 506,000                     | 703,392                        | 809,034                      |
| City of Kitchener                      | 131,801              | 208,795                     | 222,486                        | 231,514                      | 229,724                     | 319,340                        | 367,301                      |
| City of Cambridge                      | 71,482               | 116,815                     | 124,474                        | 129,525                      | 128,524                     | 178,662                        | 205,495                      |
| City of Waterloo                       | 49,972               | 86,461                      | 92,131                         | 95,869                       | 95,128                      | 132,237                        | 152,098                      |
| Township of Wellesley                  | 6,404                | 8,738                       | 9,311                          | 9,689                        | 9,614                       | 13,364                         | 15,372                       |
| Village of Wellesley                   | 842                  | 1,461                       | 1,557                          | 1,620                        | 1,608                       | 2,235                          | 2,571                        |
| Township of Wilmot                     | 10,566               | 13,337                      | 14,212                         | 14,788                       | 14,674                      | 20,398                         | 23,462                       |
| Village of New Hamburg                 | 3,628                | 4,535                       | 4,832                          | 5,028                        | 4,989                       | 6,935                          | 7,977                        |
| Township of Woolwich                   | 16,038               | 19,776                      | 21,072                         | 21,928                       | 21,758                      | 30,246                         | 34,788                       |
| Town of Elmira                         | 7,034                | 8,701                       | 9,272                          | 9,648                        | 9,574                       | 13,308                         | 15,307                       |
| Township of North Dumfries             | 4,901                | 5,979                       | 6,370                          | 6,629                        | 6,578                       | 9,144                          | 10,517                       |
| Village of Ayr                         | 1,331                | 2,143                       | 2,283                          | 2,376                        | 2,357                       | 3,277                          | 3,769                        |
| Brant County                           | 96,144               | 117,616                     | 130,155                        | 144,293                      | 149,964                     | 187,890                        | 235,489                      |
| *City of Brantford                     | 69,930               | 89,680                      | 99,239                         | 109,772                      | 120,875                     | 151,045                        | 188,575                      |
| Town of Paris                          | 6,691                | 8,000                       | 8,800                          | 9,484                        | 8,609                       | 10,921                         | 13,168                       |
| Township of Brantford                  | 6,161                | 6,558                       | 6,979                          | 7,901                        | 7,068                       | 8,106                          | 10,649                       |
| Township of Burford                    | 2,899                | 2,826                       | 3,284                          | 3,718                        | 2,735                       | 3,814                          | 5,011                        |
| Township of Oakland                    | 1,291                | 1,258                       | 1,462                          | 1,656                        | 1,218                       | 1,698                          | 2,232                        |
| Township of Onondaga                   | 1,368                | 1,333                       | 1,550                          | 1,754                        | 1,291                       | 2,039                          | 2,365                        |
| Township of Tuscarora (Indian Reserve) | 3,853                | 3,756                       | 4,365                          | 4,941                        | 3,635                       | 5,069                          | 6,660                        |
| Township of South Dumfries             | 3,951                | 4,205                       | 4,476                          | 5,067                        | 4,533                       | 5,198                          | 6,829                        |

TABLE 2.6 - (cont'd)...

## Population Projections by Municipality for the Grand River Watershed

| Municipality                                 | Population<br>(1976) | Low<br>Projection<br>(2001) | Medium<br>Projection<br>(2001) | High<br>Projection<br>(2001) | Low<br>Projection<br>(2031) | Medium<br>Projection<br>(2031) | High<br>Projection<br>(2031) |
|----------------------------------------------|----------------------|-----------------------------|--------------------------------|------------------------------|-----------------------------|--------------------------------|------------------------------|
| Dufferin County                              | 6,240                | 7,996                       | 11,469                         | 14,628                       | 10,839                      | 20,392                         | 32,107                       |
| Village of Grand Valley                      | 1,060                | 1,532                       | 1,739                          | 2,132                        | 2,383                       | 3,150                          | 4,931                        |
| Township of Amaranth                         | 1,875                | 2,405                       | 3,831                          | 4,874                        | 3,241                       | 6,939                          | 11,831                       |
| Township of East Garafraxa                   | 1,234                | 1,583                       | 2,584                          | 3,208                        | 2,133                       | 4,681                          | 7,786                        |
| Township of East Luther                      | 866                  | 1,111                       | 1,770                          | 2,666                        | 1,497                       | 3,540                          | 4,826                        |
| Township of Malancthon                       | 1,205                | 1,365                       | 1,545                          | 1,748                        | 1,585                       | 2,082                          | 2,733                        |
| Grey County                                  | 1,312                | 1,748                       | 2,048                          | 2,300                        | 2,430                       | 3,559                          | 4,633                        |
| Village of Dundalk                           | 1,130                | 1,561                       | 1,854                          | 2,094                        | 2,238                       | 3,350                          | 4,394                        |
| Township of Proton                           | 182                  | 187                         | 194                            | 206                          | 192                         | 209                            | 239                          |
| Oxford County                                | 8,030                | 9,095                       | 10,298                         | 11,651                       | 10,564                      | 13,880                         | 18,212                       |
| Township of East Zorra-Tavistock             | 796                  | 901                         | 1,021                          | 1,155                        | 1,047                       | 1,376                          | 1,805                        |
| Township of Blandford-Blenheim               | 5,959                | 6,750                       | 7,642                          | 8,646                        | 7,840                       | 10,300                         | 13,515                       |
| Township of Norwich                          | 1,275                | 1,444                       | 1,635                          | 1,850                        | 1,677                       | 2,204                          | 2,892                        |
| Perth County                                 | 4,620                | 5,197                       | 6,054                          | 7,155                        | 5,988                       | 8,403                          | 12,450                       |
| Village of Milverton                         | 701                  | 758                         | 1,029                          | 1,468                        | 832                         | 1,629                          | 3,563                        |
| Township of Wallace and Elma                 | 88                   | 100                         | 113                            | 128                          | 116                         | 152                            | 199                          |
| Township of Ellice, North and South Easthope | 1,625                | 1,840                       | 2,083                          | 2,358                        | 2,138                       | 2,809                          | 3,685                        |
| Township of Mornington                       | 2,206                | 2,499                       | 2,829                          | 3,201                        | 2,902                       | 3,813                          | 5,003                        |
| Wellington County                            | 108,840              | 138,286                     | 173,477                        | 199,120                      | 184,007                     | 307,342                        | 416,148                      |
| City of Guelph                               | 70,374               | 90,250                      | 115,456                        | 130,469                      | 121,643                     | 209,133                        | 273,669                      |
| Town of Fergus                               | 5,967                | 8,505                       | 11,133                         | 13,187                       | 11,577                      | 22,810                         | 32,009                       |
| Village of Arthur                            | 1,628                | 2,038                       | 2,200                          | 2,362                        | 2,530                       | 3,111                          | 3,692                        |
| *Village of Elora                            | 2,974                | 4,588                       | 5,355                          | 6,227                        | 7,722                       | 10,844                         | 15,114                       |
| Village of Drayton                           | 813                  | 1,042                       | 1,179                          | 1,507                        | 1,405                       | 1,843                          | 3,162                        |
| Township of Arthur                           | 622                  | 638                         | 662                            | 705                          | 657                         | 714                            | 818                          |
| Township of Eramosa                          | 4,084                | 5,237                       | 6,700                          | 8,145                        | 7,059                       | 12,137                         | 18,651                       |
| Township of Erin                             | 2,745                | 3,520                       | 4,503                          | 5,475                        | 4,745                       | 8,157                          | 12,536                       |
| Township of West Garafraxa                   | 2,215                | 2,509                       | 2,841                          | 3,214                        | 2,914                       | 3,829                          | 5,023                        |
| Township of Guelph                           | 2,862                | 3,670                       | 4,695                          | 5,708                        | 4,947                       | 8,505                          | 13,070                       |
| Township of West Luther                      | 816                  | 636                         | 837                            | 869                          | 367                         | 862                            | 936                          |
| Township of Maryborough                      | 2,025                | 2,156                       | 2,294                          | 2,597                        | 2,323                       | 2,664                          | 3,500                        |
| Township of Peel                             | 3,837                | 4,084                       | 4,347                          | 4,921                        | 4,402                       | 5,048                          | 6,632                        |
| Township of Nichol                           | 2,766                | 3,133                       | 3,547                          | 4,538                        | 3,639                       | 4,781                          | 8,220                        |
| Township of Pilkington                       | 1,840                | 2,084                       | 2,360                          | 2,670                        | 2,421                       | 3,180                          | 4,173                        |
| Township of Puslinch                         | 3,272                | 4,196                       | 5,368                          | 6,526                        | 5,636                       | 9,724                          | 14,943                       |
| TOTAL                                        | 547,786              | 778,857                     | 866,880                        | 939,043                      | 918,909                     | 1,302,609                      | 1,600,444                    |

\* With Annexation

new conservation methods are implemented, and (3) the water rate structure is modified to reflect changing water prices. Details of the methodologies used for prediction are outlined below.

#### (1) Base Case Projections

To determine future municipal water demand using the base case projection, the following methodology was used. It was assumed that the 1978 per capita rates for non-domestic user classes would remain the same in the future. For industrial consumption, this implies that the industrial profile in each municipality will remain unchanged in the future and that the industrial labour force will grow at the same rate as the total population.

To project residential water demand, water consumption was separated into two components: in-house consumption for dwelling units, and summer consumption for lawn watering.

To estimate a range in the number of dwelling units which may be necessary in the future for each urban area, the projected low, medium and high populations for the years 2001 and 2031 were divided by the anticipated future family sizes. Future family sizes are expected to decline from an average of 3.1 in the year 1976 to 2.6 in the year 2001 and remain at a stable size thereafter for the five major centres (Veale, 1980 c). The rate of consumption for apartment units and the in-house consumption rate for non-apartment dwelling units were assumed to remain at the 1978 level.

Since the volume of summer lawn sprinkling for an individual household varies with lawn size, an investigation of trends in housing and lot sizes was undertaken for the five major urban centres in order to estimate the number of non-apartment units which could be expected in the future and the average lawn sizes associated with these dwelling units (Veale, 1980 c). Results of the study revealed that it is probably reasonable to assume constant densities of 7 and 12 units per acre for semi-detached and attached (row house) units in the future. However, it is expected that the density of detached units will increase from the current level of 4.5 units

per acre to 5.6 units per acre after 1991. To predict the future mix of dwelling unit types, further analysis was carried out. The methodology used is summarized in Appendix C. The results of the study are outlined in Table 2.7.

From these data, the total number of non-apartment dwelling units was estimated and the area of lawn at the expected future density was determined for the years 2001 and 2031. Future water demand for lawn sprinkling was estimated using an observed per acre sprinkling rate (Appendix B1.2).

Following the above methodology, a drastic shift in the profile of dwelling unit types is forecast. However, current trends suggest that a drastic shift may not occur. Therefore, the base case projection was also estimated using existing proportions of dwelling types to the year 2031. These two approaches, with and without changes in the mix of housing types provide a test of water demand sensitivity to housing characteristics.

In order to estimate total pumpage, system losses must be added to total metered pumpage. For the base case projection, system losses were assumed to be a constant percentage of total pumpage. This percentage was based on 1978 losses. The volume of losses varies with metered pumpage from summer to winter because of this assumption. Seasonal variations in metered pumpage were assumed to be caused entirely by residential sprinkling demand. This assumption is supported by the analysis of seasonal non-residential and non-domestic consumption discussed in Appendix B.

## (2) Water Demand Projections Based on the Implementation of Conservation Measures

Water conservation programs can comprise a diverse range of actions that aim at reducing average day or maximum day demand; actions that can affect the flow of water at any point from the source of supply through to the end use. Water conservation programs may include leakage surveys, reductions in system pressure, metering, prohibitive pricing, building code changes, restrictions on non-essential uses, education programs and incentive

TABLE 2.7

Estimation of Future Mix of Housing Types in the Major Urban Centres

| Community           | Kitchener/Waterloo |     |     |     |      | Cambridge |     |     |     |      | Guelph |     |      | Brantford |     |      |
|---------------------|--------------------|-----|-----|-----|------|-----------|-----|-----|-----|------|--------|-----|------|-----------|-----|------|
| Population Forecast | Low                | Low | Low | Med | High | Low       | Low | Low | Med | High | Low    | Med | High | Low       | Med | High |
| % of Detached Units |                    |     |     |     |      |           |     |     |     |      |        |     |      |           |     |      |
| 1976                | 51                 |     | 51  | 51  | 51   | 57        |     | 57  | 57  | 57   | 55     | 55  | 55   | 61        | 61  | 61   |
| 2001                | 35                 |     | 34  | 34  | 33   | 39        |     | 39  | 39  | 38   | 39     | 38  | 38   | 44        | 44  | 43   |
| 2031                | 34                 |     | 33  | 31  | 31   | 38        |     | 38  | 37  | 37   | 38     | 36  | 34   | 43        | 42  | 41   |
| % Apartments        |                    |     |     |     |      |           |     |     |     |      |        |     |      |           |     |      |
| 1976                | 34                 |     | 34  | 34  | 34   | 24        |     | 24  | 24  | 24   | 30     | 30  | 30   | 21        | 21  | 21   |
| 2001                | 47                 |     | 47  | 48  | 48   | 36        |     | 36  | 36  | 36   | 41     | 42  | 42   | 33        | 33  | 33   |
| 2031                | 47                 |     | 48  | 50  | 51   | 36        |     | 36  | 38  | 38   | 42     | 44  | 46   | 34        | 35  | 36   |
| % Semi-Detached     |                    |     |     |     |      |           |     |     |     |      |        |     |      |           |     |      |
| 1976                | 5                  |     | 5   | 5   | 5    | 6         |     | 6   | 6   | 6    | 3      | 3   | 3    | 8         | 8   | 8    |
| 2001                | 11                 |     | 11  | 11  | 11   | 15        |     | 15  | 15  | 15   | 11     | 11  | 11   | 16        | 16  | 16   |
| 2031                | 11                 |     | 11  | 11  | 10   | 15        |     | 15  | 14  | 14   | 11     | 10  | 10   | 16        | 16  | 16   |
| % Attached Units    |                    |     |     |     |      |           |     |     |     |      |        |     |      |           |     |      |
| 1976                | 11                 |     | 11  | 11  | 11   | 13        |     | 13  | 13  | 13   | 12     | 12  | 12   | 9         | 9   | 9    |
| 2001                | 8                  |     | 8   | 8   | 8    | 11        |     | 11  | 11  | 11   | 9      | 9   | 9    | 7         | 7   | 7    |
| 2031                | 8                  |     | 8   | 8   | 8    | 11        |     | 11  | 11  | 11   | 9      | 10  | 10   | 7         | 7   | 8    |

programs to promote and even subsidize conservation efforts. Consumers may respond to these actions by being more conscientious about their rate of water consumption (turning off taps, fixing leaks, less lawn watering, etc.) or by investing in water conserving equipment (commercial and industrial recycling, flow reducers in taps, showers and toilets, improved appliances, etc.).

For the purpose of this study, actual and hypothetical case studies have been reviewed in order to identify savings anticipated with a water conservation program (Tables 2.8 and 2.9). With this type of analysis, double counting of the impacts of various conservation actions must be avoided. For instance, a particular program might use both higher prices and plumbing code amendments to reduce average day demand. If either action, by itself generates a 5% reduction in demand, it is unlikely that the combined effect would be 10%, since part of the response to higher prices could involve investment in the newly-sanctioned water-conserving fixtures. Evidence from observed case studies is valuable in this respect since it captures the overall observed response of community demand to combined action in a water conservation program.

New pricing policies may be one component of a water conservation program. A new policy, to be effective, must incorporate higher rates for water since only an increase in price will discourage consumption. An overall rate increase will affect all consumers. Selective rate increases brought about by modifications of the rate structure will influence only certain consumer groups or components of demand like summer lawn sprinkling.

Several hypothetical case studies suggest that average day demand can be cut by up to 12% just by modification of the domestic demand component, with the most frequent prediction of savings lying between 4% and 7%. Greatest in-house savings come from a reduction in water used for toilet flushing. The analysis of sprinkling demand summarized in Table 2.10, suggests that metering has the greatest impact. Other actions listed here give rise to a savings of 3% to 10% and are of greatest interest in this study since metering is already used in the Grand River basin. A 5% to 10% reduction in maximum day demand due to reduced sprinkling use combined with



TABLE 2.8  
Water Conservation Case Studies - Actual Programs

| Community                                           | Washington                         | Dallas,<br>Texas                         | Elmhurst,<br>Illinois    | Fairfax Co.,<br>Virginia                | Westminister,<br>Colorado                 | Gettysburg &<br>Springettsburg |
|-----------------------------------------------------|------------------------------------|------------------------------------------|--------------------------|-----------------------------------------|-------------------------------------------|--------------------------------|
| <u>% Reduction of Flow:</u>                         |                                    |                                          |                          |                                         |                                           |                                |
| (a) Average Day                                     | 14 (residential)                   | 4                                        | 15                       | 5                                       | 7.5                                       | 10                             |
| (b) Maximum Day                                     | N/A                                | 12                                       | N/A                      | 18                                      | N/A                                       | N/A                            |
| (c) Loading Factor<br>(b)/(a)                       | N/A                                | 8                                        | N/A                      | 15                                      | N/A                                       | N/A                            |
| (d) Sewage Flow                                     | N/A                                | N/A                                      | 10                       | N/A                                     | N/A                                       | N/A                            |
| <u>Program Description:</u>                         |                                    |                                          |                          |                                         |                                           |                                |
| (a) Pricing Policies                                | X (increasing<br>block)            | X (flat rate &<br>(excess use<br>charge) | X (excess use<br>charge) | X (flat rate &<br>excess use<br>charge) | X (increasing<br>block)                   |                                |
| (b) Education                                       | X                                  | X                                        | X                        | X                                       |                                           | X                              |
| (c) New Plumbing code                               | X                                  |                                          | X                        | X                                       |                                           | X                              |
| (d) Incentive Programs<br>(retro fitting,<br>other) |                                    |                                          | X                        |                                         | X                                         | X                              |
| <u>Reference:</u>                                   |                                    |                                          |                          |                                         |                                           |                                |
|                                                     | McGarry and<br>Brusnigam<br>(1978) | Rice and Shaw<br>(1978)                  | Meyer et al<br>(1978)    | Griffith (n.d.)                         | McGhee;<br>Reardon; and<br>Shulman (1978) | Sharpe (1979)                  |

N/A - Not available

TABLE 2.9  
Water Conservation Case Studies - Hypothetical Domestic Demand Programs

| Author                                                | Sharpe (1978) |     |        | North Marine County (1976) |     | Stone (1978) | Water Conservation Centre (1978) |     |        |
|-------------------------------------------------------|---------------|-----|--------|----------------------------|-----|--------------|----------------------------------|-----|--------|
|                                                       | (1)           | (2) | (3)    | (1)                        | (2) |              | (1)                              | (2) | (3)    |
| <u>% Reduction of Flow:</u>                           |               |     |        |                            |     |              |                                  |     |        |
| (a) In-house consumption                              | 30            | 39  | 12-39  | 19                         | 35  | 19-35        | 31                               | 37  | 49-62  |
| (b) Domestic sewage                                   | 50            | 0   | 30-100 | 20                         | 30  | 10-18        | 38                               | 38  | 63-100 |
| (c) Total average day consumption <sup>1</sup>        | 6             | 8   | 2-8    | 4                          | 7   | 4-7          | 6                                | 7   | 10-12  |
| <u>Conservation Methods:</u>                          |               |     |        |                            |     |              |                                  |     |        |
| (a) Change consumption habits (without devices, etc.) |               |     |        | X                          |     |              |                                  | X   | X      |
| (b) Retro fit:                                        |               |     |        |                            |     |              |                                  |     |        |
| toilets                                               | X             |     |        | X                          | X   | X            | X                                | X   |        |
| taps                                                  | X             |     |        |                            |     |              | X                                | X   | X      |
| showers                                               | X             |     |        | X                          | X   | X            | X                                | X   | X      |
| (c) New toilet                                        |               |     | X      |                            | X   |              |                                  |     | X      |
| (d) New appliances                                    |               |     |        |                            | X   | X            |                                  |     |        |
| (e) Recycling waste water                             |               | X   |        |                            |     |              |                                  |     |        |

<sup>1</sup>Assumes that in-house demand is 20% of total pumpage and that only in-house demand changes. 20% is used on the basis of information in Appendix B.

a 20% to 37% reduction in in-house domestic use (assumed to be 20% of maximum day demand) would yield an overall reduction of 9% to 17% in maximum day demand. The upper limit, based on a 62% reduction in in-house use would be a 22% reduction of maximum day demands. This discussion of data generated by hypothetical studies is summarized in Table 2.11.

The success of a water conservation program can be measured by comparing potential savings to those that are realized. From the actual case studies in Table 2.8, it is apparent that a 5% to 10% reduction in average day demand and a 10% to 20% reduction in maximum day demand can be realistically expected from a water conservation program implemented in an existing community. These savings seem to compare very favourably to savings indicated in Table 2.9 until one recalls that these actual savings come from all consumer classes and not just residential customers. Suppose residential customers contributed to a conservation effort in proportion to their share of total demand, while other customers made up the remaining contribution. A 10% drop in total demand would imply a 10% drop in residential demand. However, hypothetical residential savings range between 12% and 62%. Viewed in this light, existing water conservation programs have met with only moderate success if potential savings are the criteria for success. Of course, in new subdivisions, the chance of increasing savings is greater because of the relative ease of installing water saving fixtures during construction and no retro-fitting is required.

For water conservation demand projections, two different assumptions are made about domestic demand. The first entails a 10% reduction of in-house use and a 15% reduction of sprinkling use for all home owners; this reflects the observed experience with a low response from home owners. The second projection assumes a 29% reduction of existing in-house use; a 40% reduction of new in-house use and a 19% reduction of sprinkling demand; this reflects the potential conservation case with a high response from home owners.

Very little information on water conservation by non-residential users is available. For this reason a crude procedure was used to project the impact of water conservation efforts on this component. It was assumed

TABLE 2.10

Water Conservation Case Studies -  
Hypothetical Sprinkling Demand Programs

| Device Description    | Percentage Reduction in<br>Maximum Day Demand |         |
|-----------------------|-----------------------------------------------|---------|
|                       | Mean                                          | Range   |
| Meters (pricing)      | 40                                            | 25 - 58 |
| Pressure regulation   | 5                                             | 0 - 27  |
| Flow restriction      | 5                                             | 0 - 20  |
| Voluntary hose meters | 3                                             | 2 - 4   |
| Mandatory hose meters | 10                                            | 5 - 15  |
| Soil moisture sensors | 10                                            | 0 - 20  |

Source: Stone (1978)  
Water Conservation Centre (1978)

TABLE 2.11

Potential Impacts of Residential Savings  
In A Water Conservation Program  
(All Savings Attributed to Residential Demand Only)

| Percentage Reduction                      | Likely Range | Upper Limit |
|-------------------------------------------|--------------|-------------|
| <u>Average Day Demand:</u>                |              |             |
| In-house <sup>1</sup><br>(20% of total)   | 20 to 37     | 62          |
| Total                                     | 4 to 7       | 12          |
| <u>Maximum Day Demand:</u>                |              |             |
| In-house <sup>1</sup><br>(12% of total)   | 20 to 37     | 62          |
| Sprinkling <sup>1</sup><br>(40% of total) | 13 to 25     | 25          |
| Total                                     | 9 to 17      | 22          |

<sup>1</sup>Percent shares of each component in Total demand are based on values in Appendix B.

that water consumption rates among non-residential users with the exception of industries would remain constant while per capita industrial consumption was adjusted downward to project new industrial needs. This adjustment reflects an assumption that future industrial growth will occur only in industries that use moderate amounts of water (no paper, chemical, petroleum or primary metal products). Such an assumption would be justified if cities were reluctant to attract water intensive manufacturers into their communities (Appendix B1.3).

The final component of pumpage to be considered in the water-conservation demand projection is the system loss or unaccounted pumpage. System losses include leakage, fire fighting consumption and unmetered consumption. Leakage is generally the principal component of water losses (Keller, 1976). An engineering study would be required to accurately describe existing system losses and potential savings. Such a study was not feasible. Instead, a statistical analysis of losses for Ontario communities with populations in excess of 10,000 was used to characterize losses. The data base for the analysis came from results of a 1977 survey undertaken for the publication, National Inventory of Municipal Waterworks and Wastewater Systems in Canada, 1977 (Canada Supply and Services, 1978). Results of the analysis are as follows:

|                    |      |
|--------------------|------|
| Sample size        | = 50 |
| Median % loss      | = 19 |
| Mean % loss        | = 11 |
| Modal % loss       | = 5  |
| Standard deviation | = 8  |
| Maximum % loss     | = 39 |
| Minimum % loss     | = 1  |

#### Cell distribution:

| Range           | Count           |
|-----------------|-----------------|
| % loss <5       | = 4             |
| 5 < % loss <10  | = 20 (14 at 5%) |
| 10 < % loss <15 | = 13 (8 at 10%) |
| 15 < % loss     | = 10 (6 at 15%) |

Cities within the Grand River basin experienced an average loss of 19% in 1978 (Appendix B), 8 points above the provincial average. In light of the provincial statistics, it seemed reasonable to assume that new pumpage would include a loss component equal to 10% of total pumpage. Losses for existing pumpages were assumed to be constant, since, for existing systems, leak detection and repair is difficult and costly.

### (3) Water Demand Projections Based on Changing Water Prices

Water prices may change for two reasons: prices may be altered if new water rate structures are adopted, and prices will likely increase as costly new sources of supply are developed. Numerous studies have investigated the impact of price on water demand. The more rigorous and exhaustive studies have generally discovered a significant negative relationship; ie. as price increases demand per customer falls (Danielson, 1979; DeRooy, 1974; Grebenstern and Field, 1979; Grima, 1972; Howe and Linaweaver, 1967). For this reason, water demand projections that allow demand to respond to price changes were made.

A variety of rate structures can be adopted by municipalities. In 1980, Kitchener, Cambridge, Guelph and Brantford used a declining block rate price structure, while Waterloo charged a flat rate for water. The impact of four alternative rate structures on water consumption was also investigated for projection purposes. A description of the rate structures considered is outlined below.

1. Declining block rate - successive blocks of consumption are charged progressively lower prices. Generally the first block includes residential and small commercial consumption, the second commercial and light industrial, and the third and fourth heavy industrial use (there may, of course, be fewer or more blocks than four)
2. Flat rate - all consumption is priced at the same unit rate

3. Increasing block rate - similar to a declining block rate except that prices increase for successive blocks
4. Seasonal surcharge - flat rates apply with a surcharge levied against all summer use
5. Excess use rate - flat rate applies with a surcharge levied against any summer consumption in excess of some multiple of the average winter consumption

The merits of these various rate structures are discussed by Phillips (1977) and others (Griffith, 1977; Goolsby, 1975; Grima, 1972, Hanke and Davis, 1973; Holtz and Sebastian, 1978).

For each city, prices for the alternative rates were selected after examining capital and operating costs and consumption levels for 1978. The flat rate was estimated as a total average unit cost in 1978. The base rate for the two schemes using seasonally varied prices was estimated as a net average unit cost in 1978 (net of capital costs) in keeping with recommendations from the literature on peak-load pricing (Goolsby, 1975). Prices for the increasing block rate structure resembled existing prices for the declining block rate structures in range and overall level. New prices, selected as described above, were adjusted iteratively to satisfy the condition that the resulting revenue from water sales be within 5% of revenues obtained from observed sales in 1978. This condition on revenue applied only to revenue from the unit charge on water sales. Service charges were not included but sewerage surcharges were included if they were a component of the unit charge for water. This constraint was imposed in order to show how water utilities could modify water consumption characteristics via pricing while maintaining the same income level.

The mathematical expression used to relate price to consumption is called a demand curve. A parameter of demand curves that measures the sensitivity of consumption to price is called the price elasticity of demand. It is the ratio of the percentage change in consumption to the related percentage change in price. Demand curves are derived using a statistical analysis of

information describing the economic behaviour of consumers. For water demand, this entails an analysis of observed consumption rates and associated water prices along with other variables that influence consumption.

Many estimates of water demand curves are available. Some of these consider total community consumption (Macerollo and Ingram, 1979) while others consider only industrial consumers (DeRooy, 1974; Grebenstern, 1979) or residential consumers (Grima, 1972; Howe and Linaweaver, 1967; Howe, 1968; Kitchen, 1975). A critical factor to be considered in water demand forecasts is the impact of demand on capacity requirements. Since capacity needs are determined by maximum day demands, it was necessary to select estimates of demand curves that could be used to analyse maximum day demand.

Studies by Linaweaver and Howe (1967) and by Howe (1968) provide demand curves for residential consumption that measure average winter day use, average summer day use and maximum summer day use.

These curves provide an excellent base of data combining cross-section and time-series information. A comparable study was undertaken by Grima (1972) for southern Ontario using cross-section data only. The resultant demand curves displayed a considerably greater sensitivity of consumption to price than those predicted by Howe and Linaweaver. In fact, Grima's demand curves predicted that average summer day demand would fall below average winter day demand for certain Grand River communities when a high summer price was levied. This result did not seem credible in light of the price changes being considered. Accordingly, the Howe and Linaweaver demand curves were adopted for this study. The price elasticities of demand from these studies are compared in Table 2.12.

Little work has been done on demand curves for industrial users. From a review of two studies (DeRooy, 1974; Grebenstern, 1979), an elasticity of  $-.3$  was chosen to characterize industrial demand. This was considered a conservative estimate. Commercial and institutional consumers and apartment dwellers were assumed to be insensitive to price changes.



TABLE 2.12  
Price Elasticities of Demand for Residential Water Consumption

| Author                                                  | Grima (1972) | Howe & Linaweaver (1967)<br>and Howe (1968) |
|---------------------------------------------------------|--------------|---------------------------------------------|
| <u>Average Summer Day Demand</u>                        |              |                                             |
| (a) Elasticity                                          | -1.071       | -.931                                       |
| (b) % change in Consumption<br>for a 25% price increase | -27%         | -23%                                        |
| <u>Average Winter Day Demand</u>                        |              |                                             |
| (a) Elasticity                                          | -.751        | -.214                                       |
| (b) % change in consumption<br>for a 25% price increase | -19%         | -5%                                         |
| <u>Maximum Day Demand</u>                               |              |                                             |
| (a) Elasticity                                          | N/A          | -.671                                       |
| (b) % change in consumption<br>for a 25% price increase | N/A          | -17%                                        |

N/A - Not available

The analysis of water rate structures was not carried into the future. Rather, information about the influence of rate structures in 1978 was used as a check of the forecast previously discussed which considered water conservation measures. However, one aspect of this work was useful in forecasting the impact of higher cost sources of supply on consumption. For simplicity sake, a flat rate price structure was assumed in this part of the price analysis. The starting prices used in the first time period (1976-1980) was the flat rate price derived for the rate structure analysis.

An analysis of how total and per capita demand will behave as higher cost sources of water supply are brought on line was also investigated. To predict the impact of these new supplies on price, the source of supply costs, both operating and capital, for existing systems were identified. Annual capital costs were measured by amortizing estimated asset values over a 20 year period using a 10% interest rate. Total annual supply costs were divided by pumpage to derive an estimate of existing supply costs per 1,000 gallons ( $.455 \text{ m}^3$ ).

Annual unit operating and capital costs for new supply systems were estimated by assuming that the average pumpage rates for new surface water systems would be 50% of the design capacity while pumpage rates for ground-water systems would be 75% of the developed aquifer capacity. The difference between existing and new unit supply costs was added to the initial flat rate price when development of a new source was necessary. This method of adjusting price is consistent with marginal costs pricing, a pricing philosophy discussed by Hanke and Davis (1973) and others (Holtz and Sebastian, 1978; Goolsby, 1975; Grima, 1972).

#### 2.2.1.1 Water Demand Projections for the Cities of Kitchener and Waterloo

Since the cities of Kitchener and Waterloo display many similar water use characteristics and have a recent history of potential and actual water shortages, they are discussed together. The water shortages experienced by the two cities prompted them to implement a water conservation program

which included water use education and restrictions on lawn sprinkling. The low per capita rates for 1978 in these two communities may testify to the success of the program. Concurrently, the decrease in water use made in response to the shortages must be taken into account in the interpretation of the following projections.

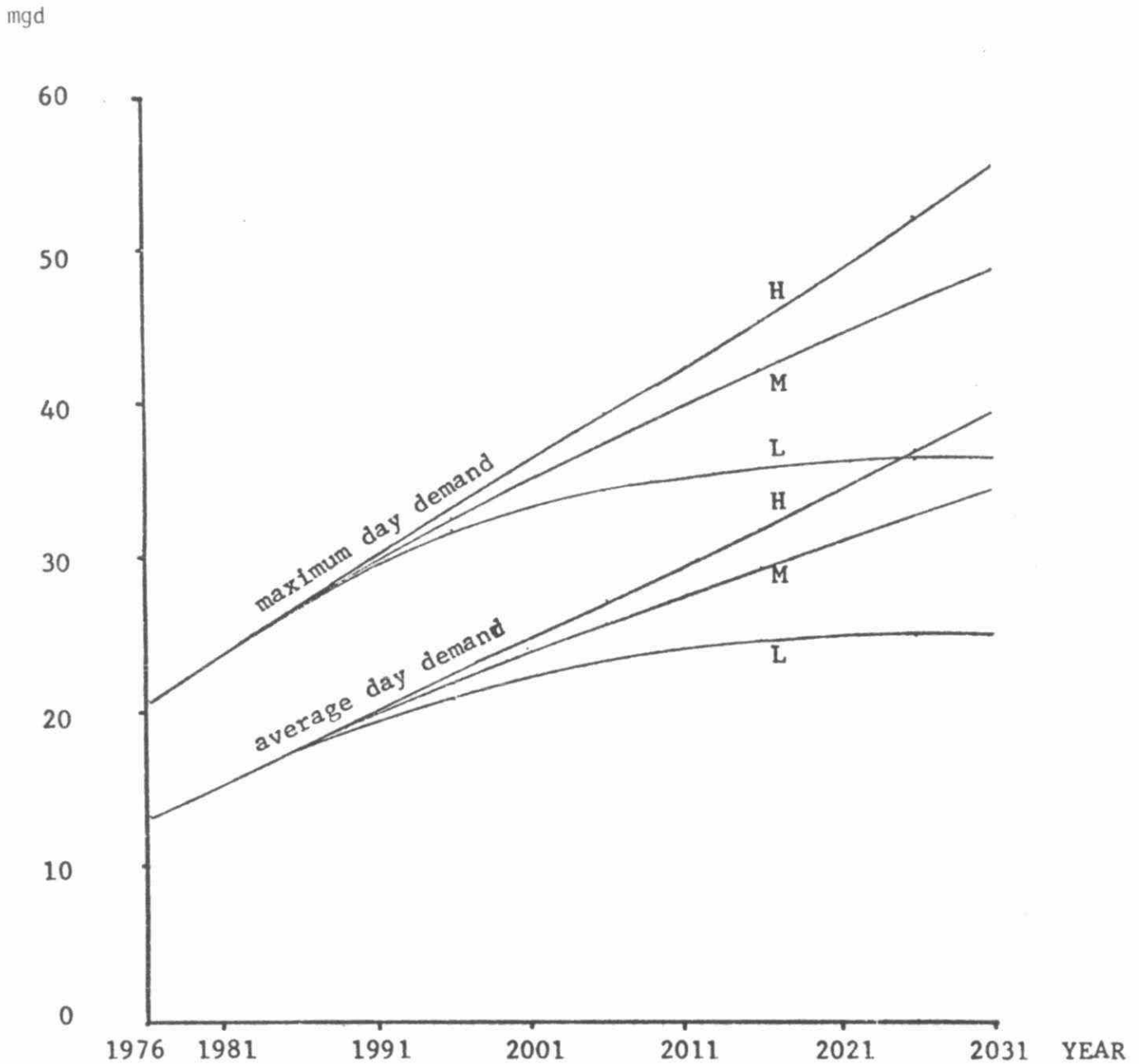
Base case projections are depicted in Figures 2.1 and 2.2. The figures indicate that population growth is a key determinant of water demand. Depending on which population projection is realized, combined capacity requirements set by maximum day use could vary up to 30 million gallons per day (mgd) ( $136\ 310\ \text{m}^3/\text{d}$ ) by the year 2031. If the medium population projection were met by the year 2031, capacity requirements would approach 70 mgd ( $318\ 190\ \text{m}^3/\text{d}$ ).

For each population projection, per capita consumption rates are projected to increase by about 5% of the observed 1978 consumption rates. This occurs because it was assumed that while residential consumption per household would remain constant, family size would decrease. The proportionately greater number of households raises the estimated future per capita pumpage rates. Alternatively, if household consumption rates were allowed to vary as a function of family size, the 5% increase projected by the projection would not likely be observed.

Base case and water conservation projections are summarized and compared in Tables 2.13 to 2.18. It is evident that the housing mix is not a critical parameter in forecasting demand. Substantially different assumptions about housing mix lead to a percentage difference of only 2% in demand and in the loading factor (Appendix C). The assumption about declining lot size is a more significant factor than housing mix since smaller lot sizes after 2001 cause the loading factor to fall by 5% to 9% between 1981 and 2031.

Under assumptions made for the low response water conservation projection, average day demand is 10% to 11% lower and maximum demand is 11% to 12% lower than those estimated in the base case projections. These savings are similar to savings which have been realized in actual case studies. However, they may be overly optimistic since certain water conservation measures have already been implemented. For the high response projection, average day demand and maximum day demand both fall by 19% to 21%.

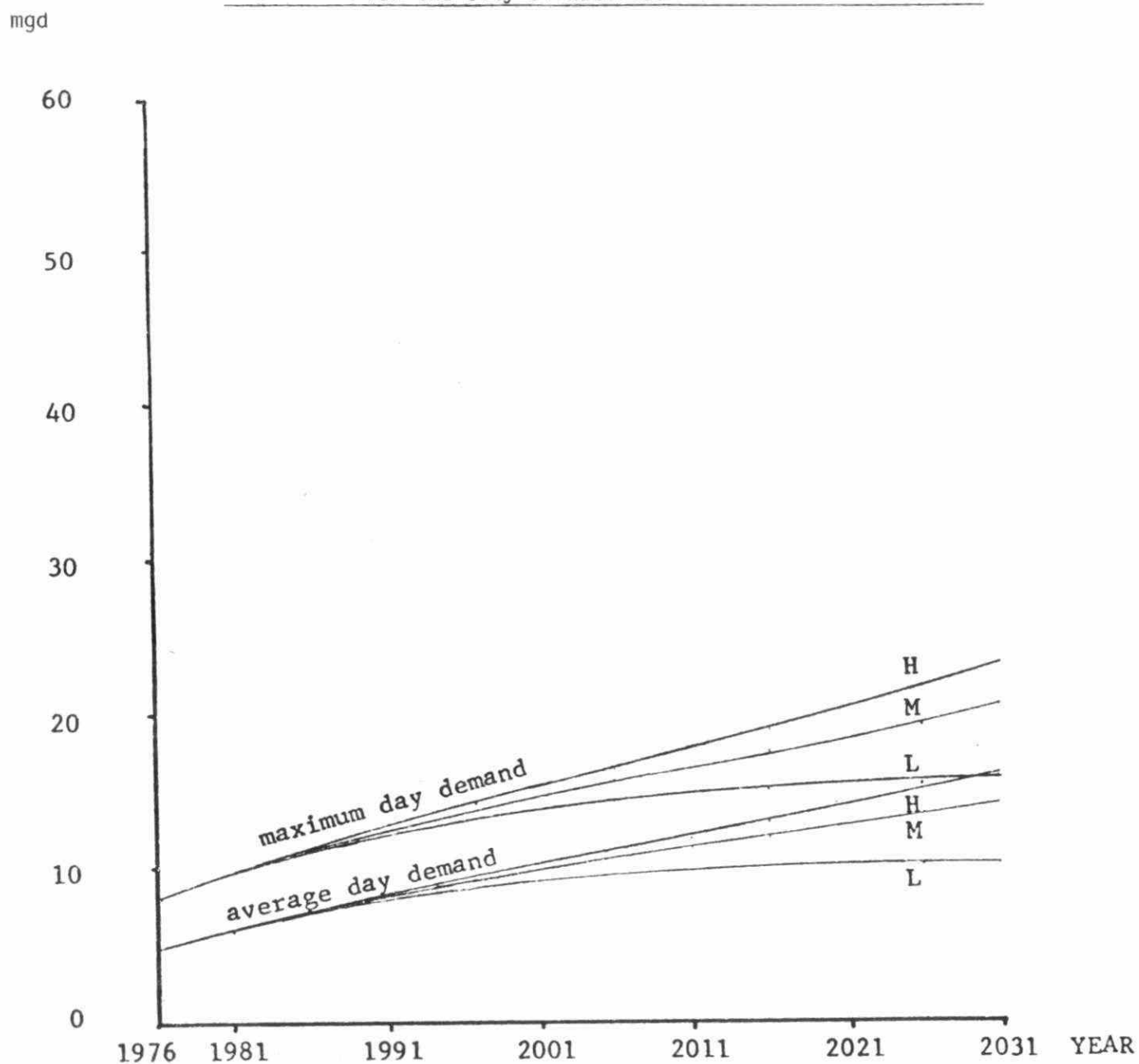
Figure 2.1 Base Case Projections with Changing Housing Mix  
Using Low, Medium and High Population Projections  
for the City of Kitchener



LEGEND

- L - Low population projection
- M - Medium population projection
- H - High population projection

Figure 2.2 Base Case Projections with Changing Housing Mix  
Using Low, Medium and High Population Projections  
for the City of Waterloo



LEGEND

- L - Low population projection
- M - Medium population projection
- H - High population projection

TABLE 2.13

## Future Water Demands for the Low Population Projection - City of Kitchener

| Year                                    | Total Pumpage (mgd) |             | Loading<br>Factor | Average Day<br>Per Capita<br>Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|-------------------|---------------------------------------------|
|                                         | Average Day         | Maximum Day |                   |                                             |
| Base Case - Fixed Housing Mix           |                     |             |                   |                                             |
| 1981                                    | 15.27               | 23.70       | 1.55              | 103.6                                       |
| 2001                                    | 22.59               | 33.85       | 1.50              | 108.2                                       |
| 2031                                    | 24.83               | 36.89       | 1.49              | 108.1                                       |
| Base Case - Changing Housing Mix        |                     |             |                   |                                             |
| 1981                                    | 15.26               | 23.59       | 1.55              | 103.6                                       |
| 2001                                    | 22.55               | 33.22       | 1.47              | 108.0                                       |
| 2031                                    | 24.78               | 36.21       | 1.46              | 107.9                                       |
| Water Conservation Case - Low Response  |                     |             |                   |                                             |
| 1981                                    | 14.36               | 21.45       | 1.49              | 97.5                                        |
| 2001                                    | 20.43               | 29.41       | 1.44              | 97.8                                        |
| 2031                                    | 22.27               | 31.87       | 1.43              | 97.0                                        |
| Water Conservation Case - High Response |                     |             |                   |                                             |
| 1981                                    | 13.12               | 19.87       | 1.51              | 89.1                                        |
| 2001                                    | 18.14               | 26.70       | 1.47              | 86.9                                        |

TABLE 2.14

## Future Water Demands for the Low Population Projection - City of Waterloo

| Year                                    | Total Pumpage (mgd) |             | Loading<br>Factor | Average Day<br>Per Capita<br>Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|-------------------|---------------------------------------------|
|                                         | Average Day         | Maximum Day |                   |                                             |
| Base Case - Fixed Housing Mix           |                     |             |                   |                                             |
| 1981                                    | 5.94                | 9.54        | 1.61              | 100.8                                       |
| 2001                                    | 9.12                | 14.09       | 1.55              | 105.5                                       |
| 2031                                    | 10.02               | 15.35       | 1.53              | 105.4                                       |
| Base Case - Changing Housing Mix        |                     |             |                   |                                             |
| 1981                                    | 5.94                | 9.49        | 1.60              | 100.8                                       |
| 2001                                    | 9.11                | 13.81       | 1.52              | 105.3                                       |
| 2031                                    | 10.01               | 15.05       | 1.50              | 105.2                                       |
| Water Conservation Case - Low Response  |                     |             |                   |                                             |
| 1981                                    | 5.54                | 8.55        | 1.54              | 94.0                                        |
| 2001                                    | 8.18                | 12.10       | 1.48              | 94.6                                        |
| 2031                                    | 8.93                | 13.12       | 1.47              | 93.9                                        |
| Water Conservation Case - High Response |                     |             |                   |                                             |
| 1981                                    | 4.94                | 7.84        | 1.58              | 84.4                                        |
| 2001                                    | 7.13                | 10.87       | 1.52              | 82.5                                        |
| 2031                                    | 7.75                | 11.75       | 1.51              | 81.5                                        |

TABLE 2.15

Future Water Demands for the Medium Population Projection -  
City of Kitchener

| Year                                    | Total Pumpage (mgd) |             | Loading<br>Factor | Average Day<br>Per Capita<br>Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|-------------------|---------------------------------------------|
|                                         | Average Day         | Maximum Day |                   |                                             |
| Base Case - Fixed Housing Mix           |                     |             |                   |                                             |
| 1981                                    | 15.27               | 23.71       | 1.55              | 103.6                                       |
| 2001                                    | 24.06               | 35.90       | 1.49              | 108.1                                       |
| 2031                                    | 34.40               | 49.79       | 1.45              | 107.7                                       |
| Base Case - Changing Housing Mix        |                     |             |                   |                                             |
| 1981                                    | 15.27               | 23.60       | 1.55              | 103.6                                       |
| 2001                                    | 24.01               | 35.23       | 1.47              | 107.9                                       |
| 2031                                    | 34.34               | 48.88       | 1.42              | 107.5                                       |
| Water Conservation Case - Low Response  |                     |             |                   |                                             |
| 1981                                    | 14.37               | 21.46       | 1.49              | 97.5                                        |
| 2001                                    | 21.64               | 31.07       | 1.44              | 97.3                                        |
| 2031                                    | 30.16               | 42.34       | 1.40              | 94.4                                        |
| Water Conservation Case - High Response |                     |             |                   |                                             |
| 1981                                    | 13.13               | 19.88       | 1.51              | 89.1                                        |
| 2001                                    | 19.17               | 28.15       | 1.47              | 86.2                                        |

TABLE 2.16

Future Water Demands for the Medium Population Projection -  
City of Waterloo

| Year                                    | Total Pumpage (mgd) |             | Loading<br>Factor | Average Day<br>Per Capita<br>Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|-------------------|---------------------------------------------|
|                                         | Average Day         | Maximum Day |                   |                                             |
| Base Case - Fixed Housing Mix           |                     |             |                   |                                             |
| 1981                                    | 5.94                | 9.55        | 1.61              | 100.8                                       |
| 2001                                    | 9.71                | 14.94       | 1.54              | 105.4                                       |
| 2031                                    | 13.88               | 20.67       | 1.49              | 105.0                                       |
| Base Case - Changing Housing Mix        |                     |             |                   |                                             |
| 1981                                    | 5.94                | 9.50        | 1.60              | 100.8                                       |
| 2001                                    | 9.70                | 14.65       | 1.51              | 105.3                                       |
| 2031                                    | 13.86               | 20.28       | 1.46              | 104.8                                       |
| Water Conservation Case - Low Response  |                     |             |                   |                                             |
| 1981                                    | 5.54                | 8.55        | 1.54              | 94.0                                        |
| 2001                                    | 8.67                | 12.79       | 1.47              | 94.1                                        |
| 2031                                    | 12.13               | 17.43       | 1.44              | 91.7                                        |
| Water Conservation Case - High Response |                     |             |                   |                                             |
| 1981                                    | 4.98                | 7.85        | 1.58              | 84.4                                        |
| 2001                                    | 7.54                | 11.46       | 1.52              | 81.8                                        |
| 2031                                    | 10.42               | 15.47       | 1.48              | 78.8                                        |

TABLE 2.17

Future Water Demands for the High Population Projection - City of Kitchener

| Year                                    | Total Pumpage (mgd) |             | Loading<br>Factor | Average Day<br>Per Capita<br>Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|-------------------|---------------------------------------------|
|                                         | Average Day         | Maximum Day |                   |                                             |
| Base Case - Fixed Housing Mix           |                     |             |                   |                                             |
| 1981                                    | 15.27               | 23.71       | 1.55              | 103.6                                       |
| 2001                                    | 25.02               | 37.23       | 1.49              | 108.1                                       |
| 2031                                    | 39.52               | 56.58       | 1.43              | 107.6                                       |
| Base Case - Changing Housing Mix        |                     |             |                   |                                             |
| 1981                                    | 15.27               | 23.60       | 1.55              | 103.6                                       |
| 2001                                    | 24.98               | 36.54       | 1.46              | 107.9                                       |
| 2031                                    | 39.45               | 55.55       | 1.41              | 107.4                                       |
| Water Conservation Case - Low Response  |                     |             |                   |                                             |
| 1981                                    | 14.37               | 21.46       | 1.49              | 97.5                                        |
| 2001                                    | 22.43               | 32.15       | 1.43              | 96.9                                        |
| 2031                                    | 34.37               | 47.85       | 1.39              | 93.6                                        |
| Water Conservation Case - High Response |                     |             |                   |                                             |
| 1981                                    | 13.13               | 19.88       | 1.51              | 89.1                                        |
| 2001                                    | 19.84               | 29.10       | 1.47              | 85.7                                        |

TABLE 2.18

Future Water Demands for the High Population Projection - City of Waterloo

| Year                                    | Total Pumpage (mgd) |             | Loading Factor | Average Day Per Capita Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|----------------|---------------------------------------|
|                                         | Average Day         | Maximum Day |                |                                       |
| Base Case - Fixed Housing Mix           |                     |             |                |                                       |
| 1981                                    | 5.94                | 9.55        | 1.61           | 100.8                                 |
| 2001                                    | 10.10               | 15.49       | 1.53           | 105.4                                 |
| 2031                                    | 15.94               | 23.47       | 1.47           | 104.8                                 |
| Base Case - Changing Housing Mix        |                     |             |                |                                       |
| 1981                                    | 5.94                | 9.50        | 1.60           | 100.8                                 |
| 2001                                    | 10.09               | 15.19       | 1.51           | 105.2                                 |
| 2031                                    | 15.92               | 23.03       | 1.45           | 104.7                                 |
| Water Conservation Case - Low Response  |                     |             |                |                                       |
| 1981                                    | 5.54                | 8.55        | 1.54           | 94.0                                  |
| 2001                                    | 9.00                | 13.24       | 1.47           | 93.8                                  |
| 2031                                    | 13.84               | 19.70       | 1.42           | 91.0                                  |
| Water Conservation Case - High Response |                     |             |                |                                       |
| 1981                                    | 4.98                | 7.85        | 1.58           | 84.4                                  |
| 2001                                    | 7.81                | 11.85       | 1.52           | 81.5                                  |
| 2031                                    | 11.84               | 17.43       | 1.47           | 77.9                                  |



The impact of various rate structures on water consumption is summarized in Tables 2.19 and 2.20.

Only three new rate structures were tested for Waterloo since the existing system already uses flat rate pricing. Neither the flat rate structure in Kitchener nor the increasing block rate structures in Kitchener and in Waterloo had significant impacts on consumption. The loading factor increased marginally with the increasing block rate because a lower price is levied on domestic lawn sprinkling. The two rate structures with special summer charges had a marked impact on maximum day demand and the loading factor. A seasonal surcharge depressed maximum day use by 7% to 9% while the more severe excess use rate depressed it by 13% to 19%. Impacts of this magnitude have been observed in practice (Table 2.8) and are quite close to the forecast low response water conservation case impacts.

To analyze the impact of increasing supply costs on water demand, a flat rate schedule was projected into the future. Several supply projects were considered in this analysis including induced infiltration, ground-water recharge at Mannheim, ground water from Roseville, and pipelines from the proposed Montrose and Ayr reservoirs and Lake Erie.

As evidenced in Figures 2.3 and 2.4 the expensive pipeline projects could have a considerable impact on consumption rates. In the limit defined by the upper range of price associated with the Lake Erie pipeline, average day demand falls by 11% and 13% and maximum day demand by 22% and 20% in Waterloo and Kitchener respectively.

The greater sensitivity of maximum day demand causes a progressive decline of the loading factor as price increases. However, these results should be received with the same reservations attached to any extrapolations using statistically calibrated models.

Four different projections based on medium population projections for the two cities are compared in Figures 2.5 and 2.6 including: (1) base case projection with a changing house mix, (2) water conservation projection,

TABLE 2.19

Impact of New Rate Structures on Water Consumption - City of Kitchener, 1978

| Rate Structure                                    | Existing Increasing Block | Flat Rate | Increasing Block | Seasonal Surcharge | Excess Use |
|---------------------------------------------------|---------------------------|-----------|------------------|--------------------|------------|
| <u>Prices Charged<sup>1</sup> (\$/1,000 gal):</u> |                           |           |                  |                    |            |
| First block<br>(3,115-105,910 gal/mo)             | 1.24                      | 1.29      | 1.21             | 1.05               | 1.19       |
| Second block<br>(105,911-186,900 gal/mo)          | 1.12                      | 1.29      | 1.32             | 1.05               | 1.19       |
| Third block<br>(>186,900 gal/mo)                  | 1.03                      | 1.29      | 1.43             | 1.05               | 1.19       |
| Summer Rate                                       | N/A                       | N/A       | N/A              | 1.85               | 2.42       |
| <u>Average Day Pumpage:</u>                       |                           |           |                  |                    |            |
| Total (mgd)                                       | 13.80                     | 13.46     | 13.38            | 13.51              | 13.40      |
| Per capita (gpcd)                                 | 103                       | 101       | 100              | 101                | 100        |
| <u>Maximum Day Pumpage (mgd):</u>                 | 21.39                     | 20.89     | 21.13            | 19.37              | 18.32      |
| Loading Factor                                    | 1.55                      | 1.55      | 1.58             | 1.43               | 1.37       |

<sup>1</sup>Prices include a sewer surcharge. \$1.49/1,000 gal charged on water below 3,116 gallons per month under existing rates. Few consumers remain within this block.

N/A - Not applicable.

TABLE 2.20

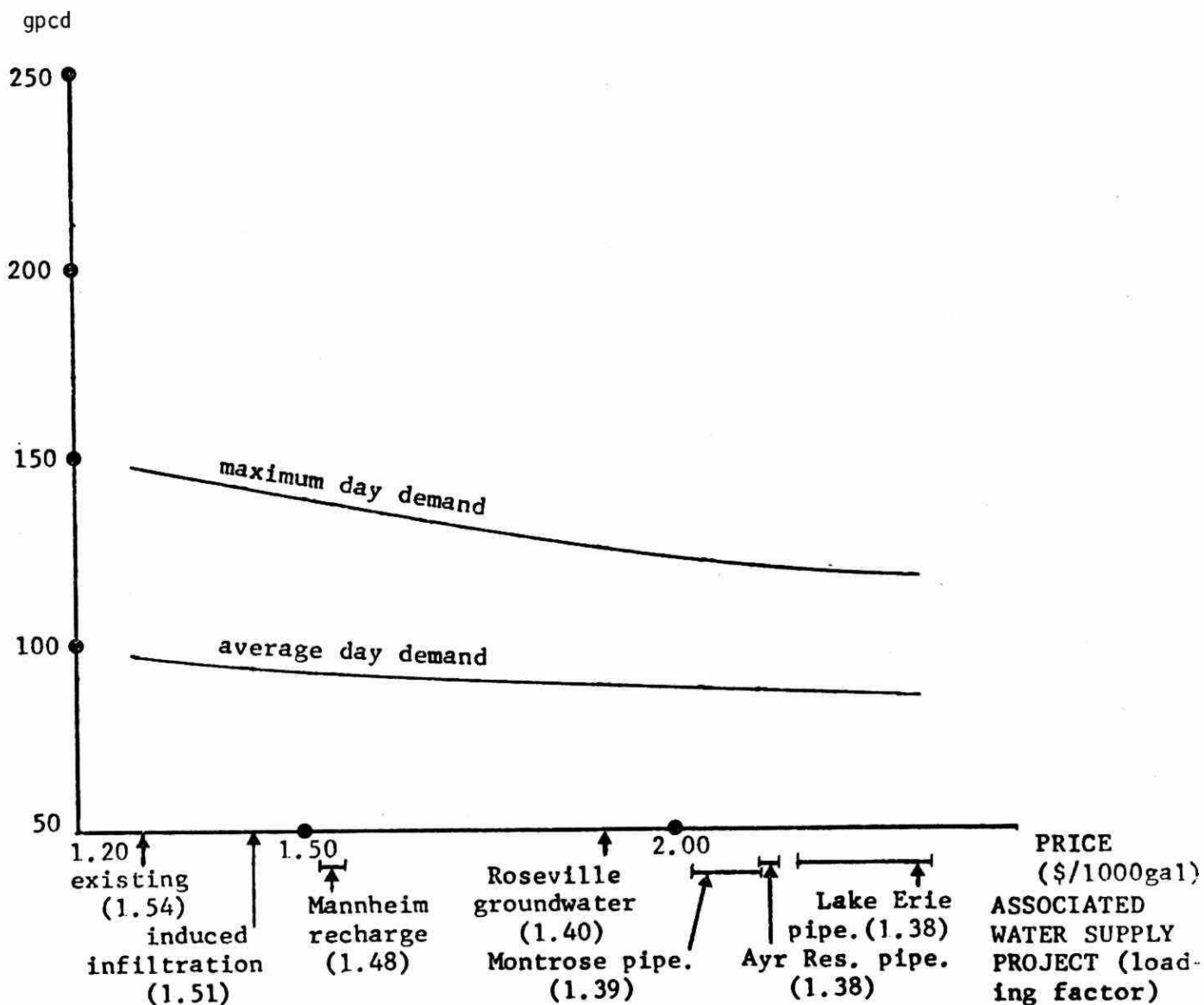
Impact of New Rate Structures on Water Consumption - City of Waterloo, 1978

| Rate Structure                                    | Existing Flat Rate | Increasing Block | Seasonal Surcharge | Excess Use |
|---------------------------------------------------|--------------------|------------------|--------------------|------------|
| <u>Prices Charged<sup>1</sup> (\$/1,000 gal):</u> |                    |                  |                    |            |
| First Block<br>(3,115-105,911 gal/mo)             | 1.06               | 1.02             | .88                | 1.02       |
| Second Block<br>(>105,911 gal/mo)                 | 1.06               | 1.19             | .88                | 1.02       |
| Summer Rate                                       | N/A                | N/A              | 1.47               | 1.88       |
| <u>Average Day Pumpage:</u>                       |                    |                  |                    |            |
| Total (mgd)                                       | 5.11               | 5.05             | 5.14               | 5.10       |
| Per capita (gpcd)                                 | 99                 | 98               | 100                | 99         |
| <u>Maximum Day Pumpage (mgd):</u>                 |                    |                  |                    |            |
| Loading Factor                                    | 1.65               | 1.68             | 1.53               | 1.44       |

<sup>1</sup>Prices include a sewer surcharge. Few customers would remain in the first block of 0-3,115 gallons per month in the increasing block rate test. Consumption blocks here were fashioned after those in Kitchener.

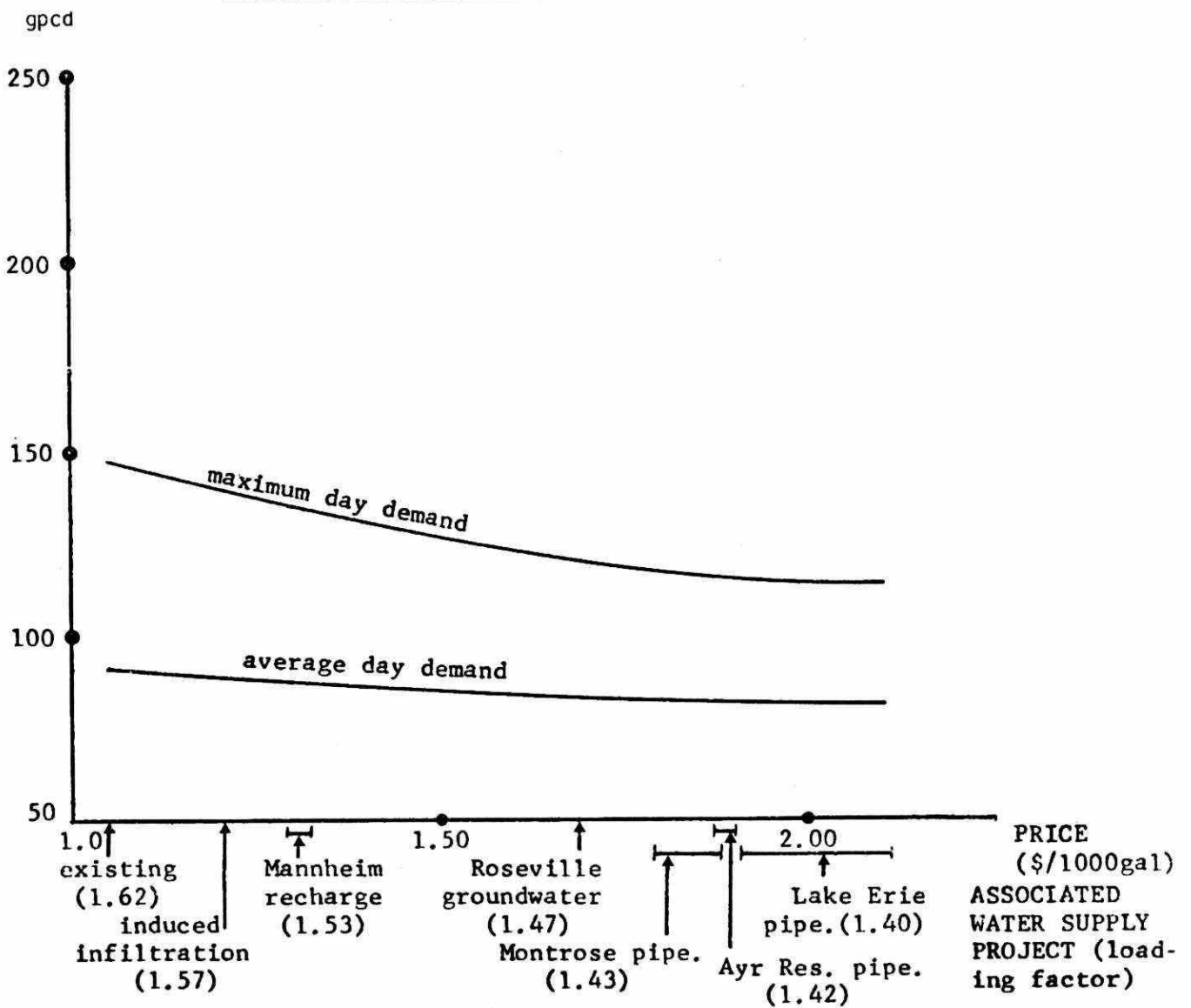
N/A - Not applicable.

Figure 2.3 Impact of Price on Per Capita Consumption Rates  
in the City of Kitchener, as Supply Costs Increase



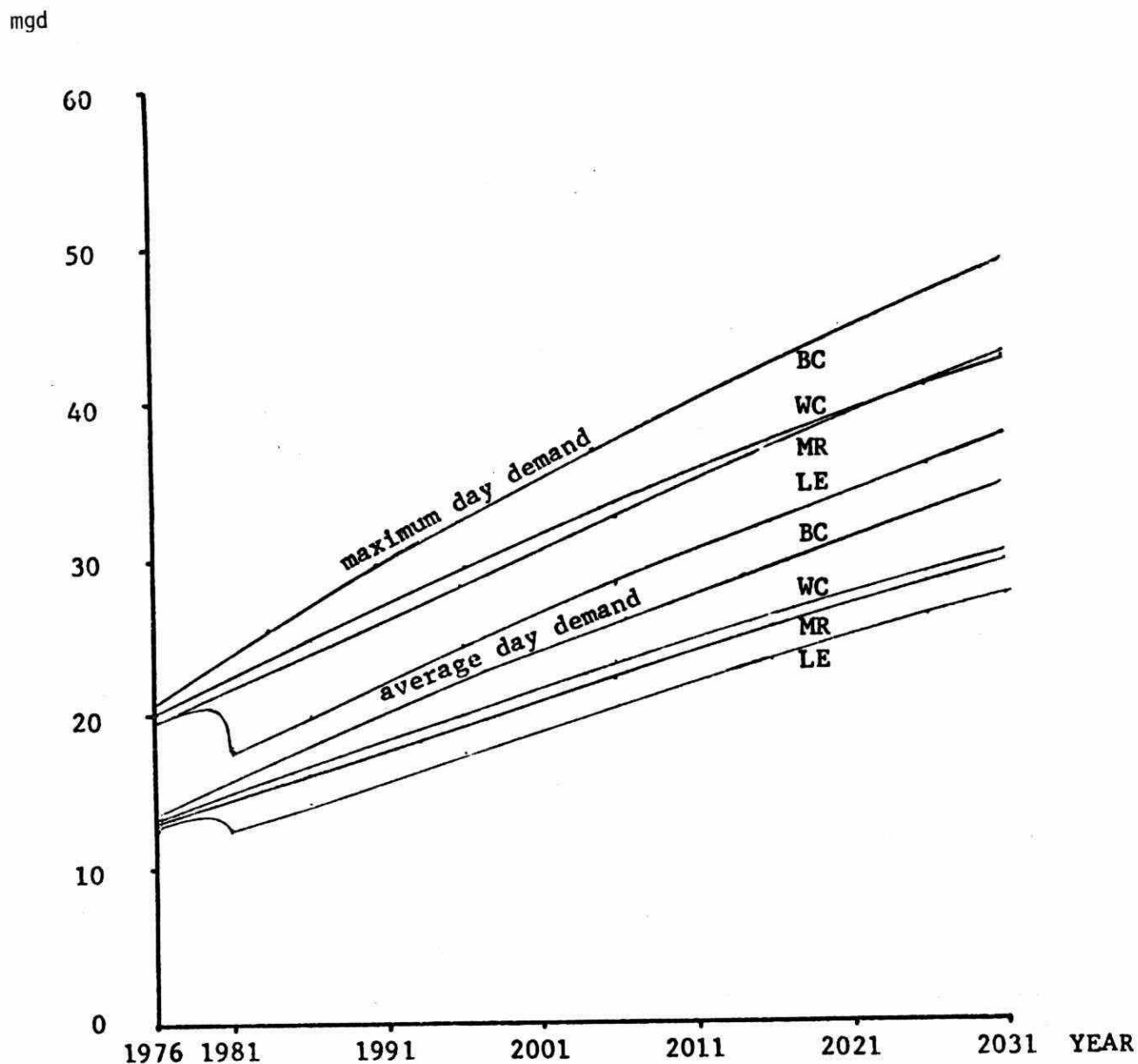
NOTE: - A flat rate price structure is assumed. Per capita consumption rates were not significantly affected by the level of population growth unless project costs varied with predicted growth rates.

Figure 2.4 Impact of Price on Per Capita Consumption Rates  
in the City of Waterloo as Supply Costs Increase



NOTE: - A flat rate price structure is assumed. Per capita consumption rates were not significantly affected by the level of population growth unless project costs varied with predicted growth rates.

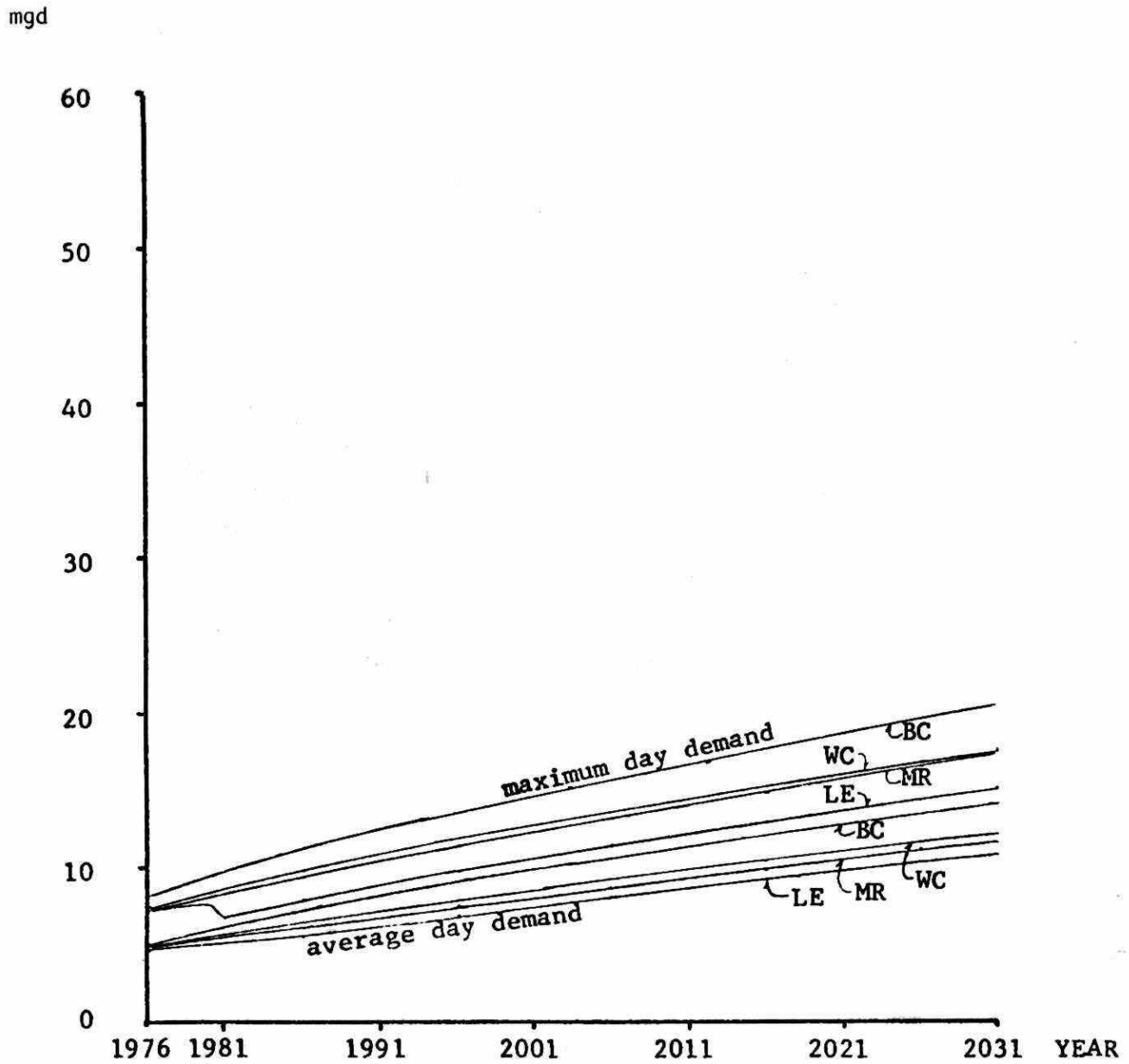
Figure 2.5 Comparison of Water Demand Projections Using  
Medium Population Projections for the City of Kitchener



LEGEND

- BC - Base case with changing housing mix
- WC - Water conservation, low response
- MR - Pricing based on Mannheim recharge
- LE - Pricing based on Lake Erie pipeline

Figure 2.6 Comparison of Water Demand Projections Using  
Medium Population Projections for the City of Waterloo



LEGEND

- BC - Base case with changing housing mix
- WC - Water conservation, low response
- MR - Pricing based on Mannheim recharge
- LE - Pricing based on Lake Erie pipeline

low response, (3) pricing based on Mannheim recharge, and (4) pricing based on Lake Erie pipeline. The lowest projections incorporated flat rate prices that reflect use of the Lake Erie pipeline. These show a precipitous drop in 1981, the year in which the project is assumed to be brought on line. The base case projection is invariably the highest projection since it fails to account for possible modifications in water consumption habits on the part of users. The weight of the evidence suggests that consumption will fall below the base projection implying a constant or falling per capita rate. However, the analysis here exaggerates these reductions because it fails to take into account the effects of past conservation efforts.

#### 2.2.1.2 Water Demand Projections for the City of Cambridge

Generally, the discussion of projections made for Kitchener and Waterloo apply equally well for Cambridge. Population is a key factor in estimating demand, while the housing mix is not. A falling family size causes per capita consumption to increase (Tables 2.21 to 2.23 and Figure 2.7).

The water conservation programs used in this analysis are more effective than in Kitchener and Waterloo. This situation can be attributed to higher initial system losses and a large number of water intensive industries. For the low response case, average day demand falls 15% to 17% and maximum day demand falls 16% to 18%; for the high response case corresponding changes are 24% to 27% and 24% to 26%. With the low response case, per capita consumption falls to levels observed elsewhere in the Regional Municipality of Waterloo.

Flat rate and increasing block rate pricing have little impact on overall demand. Essentially, they tend to reallocate demand so that domestic consumption increases while industrial consumption falls. All consumers face higher summer prices under the seasonal surcharge and excess use schemes so that maximum day consumption falls off by up to 14% (Table 2.24).



TABLE 2.21

## Future Water Demands for the Low Population Projection - City of Cambridge

| Year                                    | Total Pumpage (mgd) |             | Loading Factor | Average Day Per Capita Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|----------------|---------------------------------------|
|                                         | Average Day         | Maximum Day |                |                                       |
| Base Case - Fixed Housing Mix           |                     |             |                |                                       |
| 1981                                    | 9.67                | 14.60       | 1.51           | 116.0                                 |
| 2001                                    | 14.17               | 20.83       | 1.47           | 121.3                                 |
| 2031                                    | 15.57               | 22.75       | 1.46           | 121.2                                 |
| Base Case - Changing Housing Mix        |                     |             |                |                                       |
| 1981                                    | 9.67                | 14.46       | 1.50           | 115.9                                 |
| 2001                                    | 14.13               | 20.03       | 1.42           | 120.9                                 |
| 2031                                    | 15.53               | 21.97       | 1.41           | 120.9                                 |
| Water Conservation Case - Low Response  |                     |             |                |                                       |
| 1981                                    | 8.79                | 12.81       | 1.46           | 105.4                                 |
| 2001                                    | 11.77               | 16.63       | 1.41           | 100.8                                 |
| 2031                                    | 12.70               | 17.92       | 1.41           | 98.8                                  |
| Water Conservation Case - High Response |                     |             |                |                                       |
| 1981                                    | 7.98                | 11.82       | 1.48           | 95.7                                  |
| 2001                                    | 10.38               | 15.01       | 1.45           | 88.8                                  |

TABLE 2.22

## Future Water Demands for the Medium Population Projection - City of Cambridge

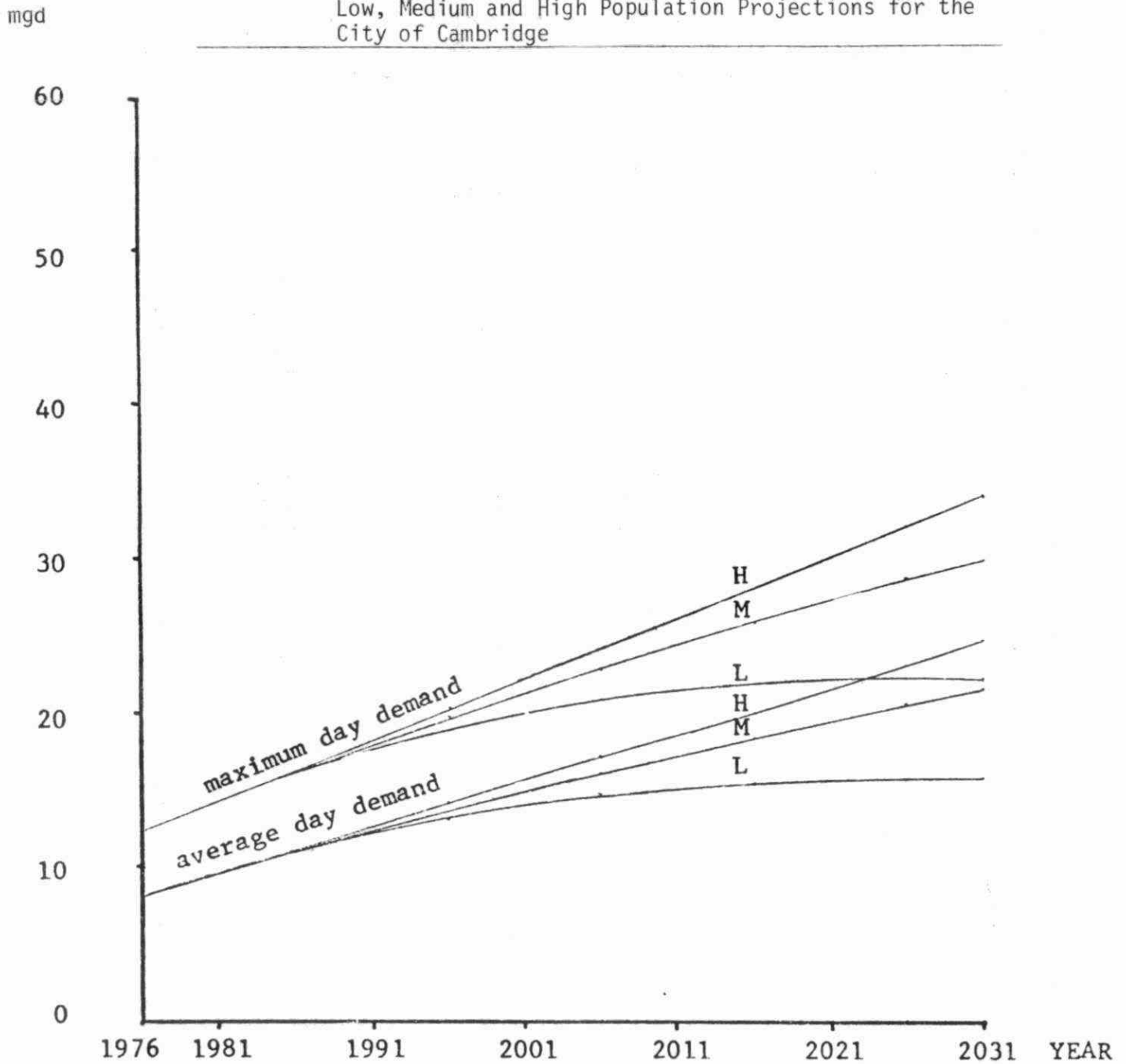
| Year                                    | Total Pumpage (mgd) |             | Loading Factor | Average Day               |
|-----------------------------------------|---------------------|-------------|----------------|---------------------------|
|                                         | Average Day         | Maximum Day |                | Per Capita Pumpage (gpcd) |
| Base Case - Fixed Housing Mix           |                     |             |                |                           |
| 1981                                    | 9.68                | 14.61       | 1.51           | 116.0                     |
| 2001                                    | 15.09               | 22.12       | 1.47           | 121.2                     |
| 2031                                    | 21.60               | 30.94       | 1.43           | 120.9                     |
| Base Case - Changing Housing Mix        |                     |             |                |                           |
| 1981                                    | 9.67                | 14.47       | 1.50           | 115.9                     |
| 2001                                    | 15.05               | 21.30       | 1.42           | 120.9                     |
| 2031                                    | 21.55               | 29.92       | 1.39           | 120.6                     |
| Water Conservation Case - Low Response  |                     |             |                |                           |
| 1981                                    | 8.80                | 12.82       | 1.46           | 105.4                     |
| 2001                                    | 12.38               | 17.50       | 1.41           | 99.5                      |
| 2031                                    | 16.63               | 23.30       | 1.40           | 93.1                      |
| Water Conservation Case - High Response |                     |             |                |                           |
| 1981                                    | 7.99                | 11.82       | 1.48           | 95.7                      |
| 2001                                    | 10.87               | 15.76       | 1.45           | 87.4                      |
| 2031                                    | 14.37               | 20.72       | 1.44           | 80.4                      |

TABLE 2.23

Future Water Demands for the High Population Projection - City of Cambridge

| Year                                    | Total Pumpage (mgd) |             | Loading<br>Factor | Average Day<br>Per Capita<br>Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|-------------------|---------------------------------------------|
|                                         | Average Day         | Maximum Day |                   |                                             |
| Base Case - Fixed Housing Mix           |                     |             |                   |                                             |
| 1981                                    | 9.68                | 14.61       | 1.51              | 116.0                                       |
| 2001                                    | 15.70               | 22.96       | 1.46              | 121.2                                       |
| 2031                                    | 24.83               | 35.28       | 1.42              | 120.8                                       |
| Base Case - Changing Housing Mix        |                     |             |                   |                                             |
| 1981                                    | 9.67                | 14.47       | 1.50              | 115.9                                       |
| 2001                                    | 15.66               | 22.14       | 1.41              | 120.9                                       |
| 2031                                    | 24.77               | 34.14       | 1.38              | 120.5                                       |
| Water Conservation Case - Low Response  |                     |             |                   |                                             |
| 1981                                    | 8.80                | 12.82       | 1.46              | 105.4                                       |
| 2001                                    | 12.78               | 18.05       | 1.41              | 98.6                                        |
| 2031                                    | 18.73               | 26.14       | 1.40              | 91.2                                        |
| Water Conservation Case - High Response |                     |             |                   |                                             |
| 1981                                    | 7.99                | 11.82       | 1.48              | 95.7                                        |
| 2001                                    | 11.20               | 16.23       | 1.45              | 86.5                                        |
| 2031                                    | 16.10               | 23.16       | 1.44              | 78.3                                        |

Figure 2.7 Base Case Projections with Changing Housing Mix Using Low, Medium and High Population Projections for the City of Cambridge



LEGEND

- L - Low population projections
- M - Medium population projections
- H - High population projections

TABLE 2.24

Impact of New Rate Structures on Water Consumption - City of Cambridge, 1978

| Rate Structure                                    | Existing Increasing Block | Flat Rate | Increasing Block | Seasonal Surcharge | Excess Use |
|---------------------------------------------------|---------------------------|-----------|------------------|--------------------|------------|
| <u>Prices Charged<sup>1</sup> (\$/1,000 gal):</u> |                           |           |                  |                    |            |
| First Block<br>(0-75,000 gal/mo)                  | 1.07                      | 1.01      | .99              | .82                | .99        |
| Second Block<br>(>75,000 gal/mo)                  | .87                       | 1.01      | 1.21             | .82                | .99        |
| Summer Rate                                       | N/A                       | N/A       | N/A              | 1.52               | 2.08       |
| <u>Average Day Pumpage:</u>                       |                           |           |                  |                    |            |
| Total (mgd)                                       | 8.37                      | 8.30      | 8.18             | 8.34               | 8.27       |
| Per capita (gpcd)                                 | 115                       | 114       | 112              | 114                | 113        |
| <u>Maximum Day Pumpage (mgd):</u>                 | 12.89                     | 12.98     | 12.93            | 11.92              | 11.10      |
| Loading Factor                                    | 1.54                      | 1.56      | 1.58             | 1.43               | 1.34       |

<sup>1</sup>Prices include sewer surcharge.

N/A - Not applicable.

The impact of future costs on consumption may be important in Cambridge because of the likelihood of high supply costs in the future. The anticipated range of costs for Cambridge is similar to the range for Kitchener and Waterloo. The Lake Erie pipeline is cheaper on a unit basis for Cambridge because of the need for an additional pumping station to lift the water from Cambridge to Kitchener. If the Cambridge system is connected to Kitchener, then supply costs for projects like the Mannheim recharge scheme and the reservoir pipelines will determine water prices in Cambridge. Over the anticipated price range, average day demand falls 12% and maximum day demand falls 22%. The loading factor falls by 12% (Figure 2.8).

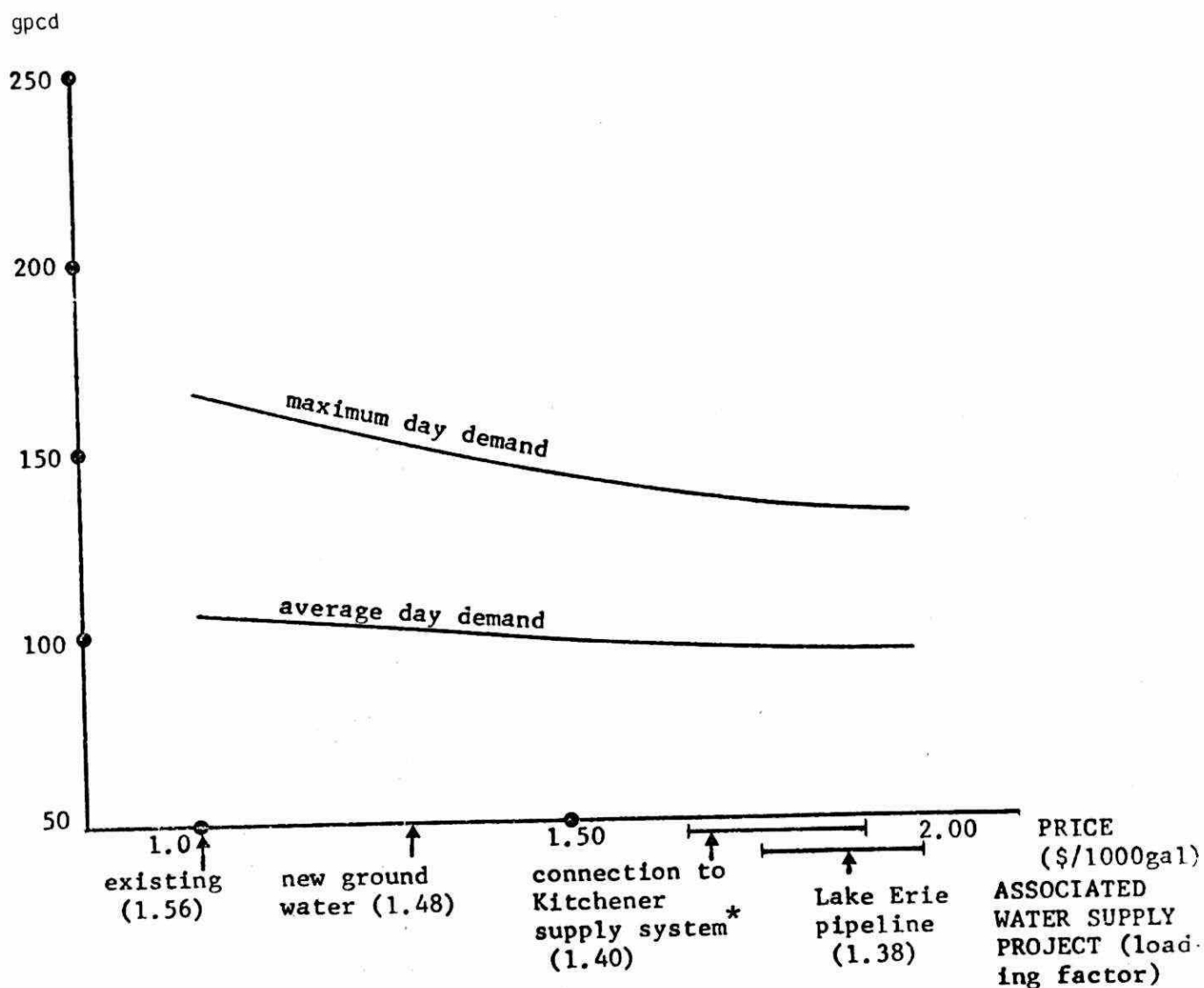
Four different projections based on the medium population projection for the City are compared in Figure 2.9 including: (1) base case projection with a changing housing mix, (2) water conservation projection, low response, (3) pricing based on Mannheim recharge, and (4) pricing based on Lake Erie pipeline. The Lake Erie pipeline pricing projection lies closer to the Mannheim recharge projection than in the Kitchener and Waterloo projections because the associated prices are closer. The base case projection is consistently above the other projections which are all relatively close to each other. Actual demand will probably fall below the base case as inexpensive supplies are exhausted.

#### 2.2.1.3 Water Demand Projections for the City of Guelph

The base case projection for the City of Guelph is outlined in Figure 2.10. As with the Cities of Kitchener and Waterloo, population growth is a key determinant of water demand. By the year 2031, capacity requirements based on maximum day use could vary by 30 mgd ( $136.37 \text{ m}^3/\text{d}$ ) depending on which population projection is realized. Per capita increases were noted in the base case projections since family size was assumed to decrease while household consumption was assumed to remain constant.

The low response water conservation projection reduces average day demand by 13% to 21% and maximum day demand by 15% to 21%. For the high response case, average day demand decreases by 22% to 30% and maximum day demand

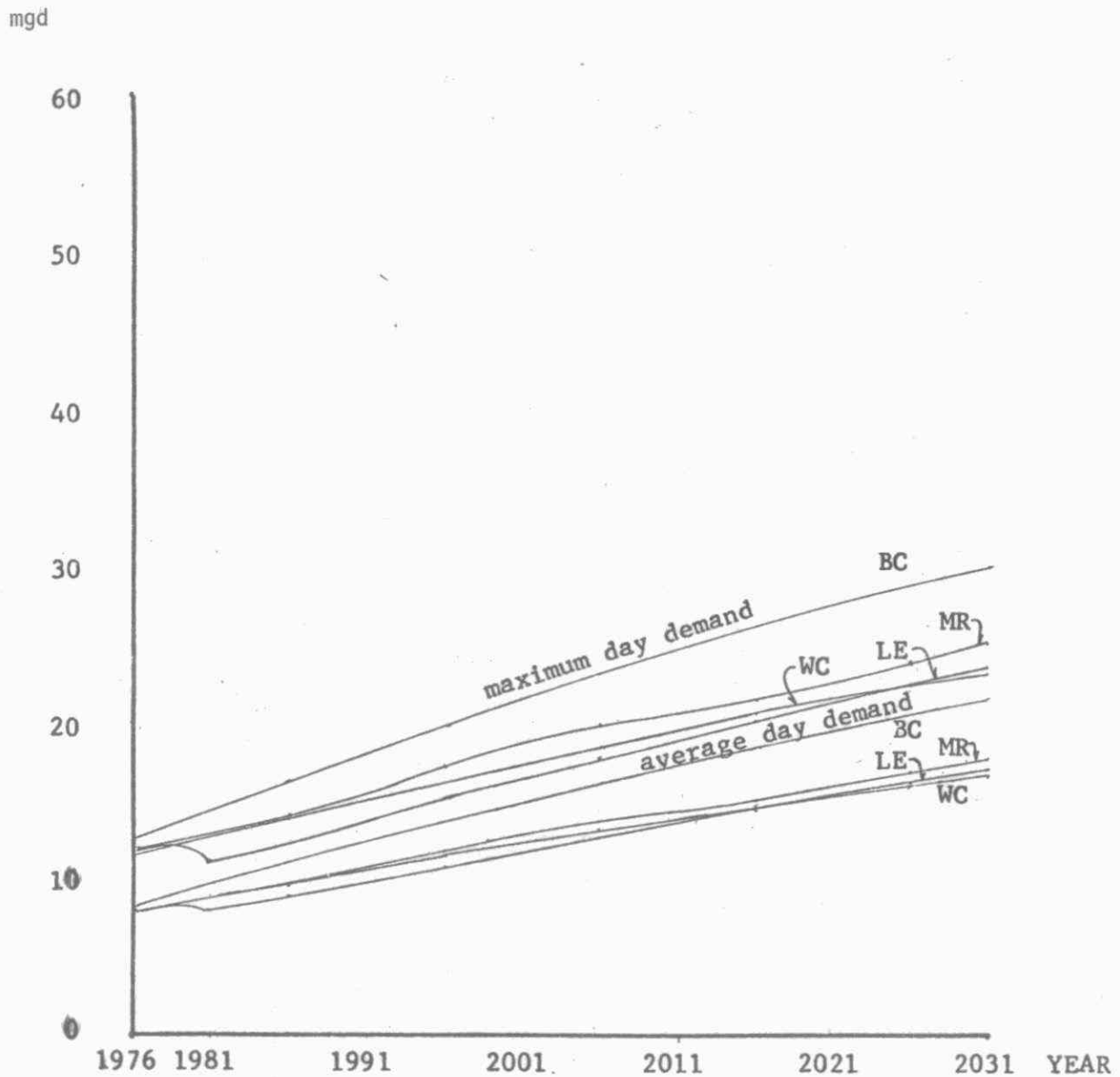
Figure 2.8 Impact of Price on Per Capita Consumption Rates in the City of Cambridge as Supply Costs Increase



NOTE: - A flat rate price structure is assumed. Per capita consumption rates were not significantly affected by the level of population growth unless project costs varied with predicted growth rates.

\* With a connection to the Kitchener/Waterloo system, the price depends on the type of supply system in Kitchener/Waterloo.

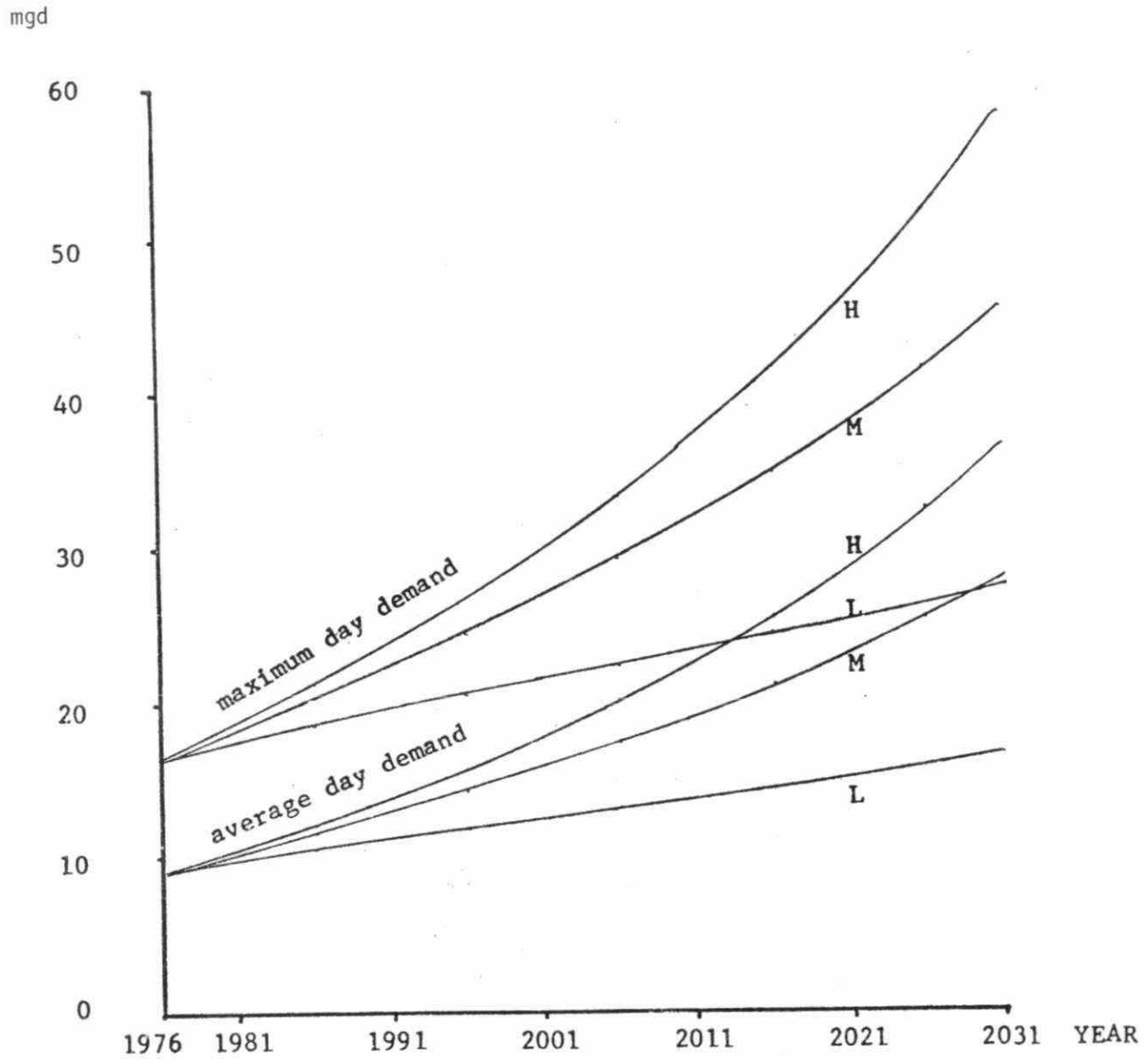
Figure 2.9 Comparison of Water Demand Projections Using  
Medium Population Projections for the City of Cambridge



LEGEND

- BC - Base case with changing housing mix
- MR - Pricing based on Mannheim recharge
- LE - Pricing based on Lake Erie pipeline
- WC - Water conservation, low response

Figure 2.10 Base Case Projections with Changing Housing Mix  
Using Low, Medium and High Population Projections for  
the City of Guelph



LEGEND

- L - Low population projection
- M - Medium population projection
- H - High population projection



falls by 22% to 28%. The impact of water conservation is greater in Guelph than in Kitchener and Waterloo because system losses are initially higher (23% compared to 10% and 12%) and because the existing industrial mix is more heavily weighted towards large scale consumers (Table 2.4).

Therefore, the potential for savings is greater. Conversely, the need for conservation may not be as great because of the current robust supply situation in Guelph.

Base case and water conservation projections are summarized and compared in Tables 2.25 to 2.27. These tables indicate that the assumptions used regarding housing mix are not critical in forecasting water demand for the City. The impact of a new rate structure is more prominent in Guelph than in Kitchener and Waterloo because demand curves are more sensitive to price changes in the lower regions (low price, high consumption) than in the higher regions (high price, low consumption) and Guelph's starting point is lower than that of Kitchener or Waterloo. Consequently, both the flat rate and the increasing block rates reduce per capita consumption. However, maximum day demand is not significantly affected because home owners actually enjoy a lower unit price. This reduction in price comes about because water sales revenue is assumed to remain unchanged. With falling average day and constant maximum day demand, the loading factor rises. Both the average and the maximum day demands fall under the rate structures that include a special summer charge. Predicted changes are consistent with actual conservation case studies but are less than the water conservation projections (see Table 2.8)

The impact of rising supply costs are depicted in Figure 2.11. This analysis may not be applicable since distant ground-water sources are currently considered necessary only if high population growth rates are realized and even then, local sources will suffice up to the year 2026. The distant ground-water supplies have not been carefully identified or costed. As with values in Table 2.27, the slope of lines in Figure 2.12 indicate the potential for price induced reductions in consumption in Guelph.

TABLE 2.25

Future Water Demands for the Low Population Projection - City of Guelph

| Year                                    | Total Pumpage (mgd) |             | Loading<br>Factor | Average Day                  |
|-----------------------------------------|---------------------|-------------|-------------------|------------------------------|
|                                         | Average Day         | Maximum Day |                   | Per Capita<br>Pumpage (gpcd) |
| Base Case - Fixed Housing Mix           |                     |             |                   |                              |
| 1981                                    | 9.80                | 17.54       | 1.79              | 129.0                        |
| 2001                                    | 12.41               | 21.60       | 1.74              | 134.5                        |
| 2031                                    | 16.58               | 28.08       | 1.69              | 134.1                        |
| Base Case - Changing Housing Mix        |                     |             |                   |                              |
| 1981                                    | 9.80                | 17.51       | 1.79              | 129.0                        |
| 2001                                    | 12.40               | 21.37       | 1.72              | 134.4                        |
| 2031                                    | 16.57               | 27.76       | 1.68              | 134.0                        |
| Water Conservation Case - Low Response  |                     |             |                   |                              |
| 1981                                    | 9.16                | 15.67       | 1.71              | 120.6                        |
| 2001                                    | 10.77               | 18.13       | 1.68              | 116.7                        |
| 2031                                    | 13.22               | 22.18       | 1.68              | 106.9                        |
| Water Conservation Case - High Response |                     |             |                   |                              |
| 1981                                    | 8.39                | 14.59       | 1.74              | 110.5                        |
| 2001                                    | 9.65                | 16.67       | 1.73              | 104.6                        |

TABLE 2.26

Future Water Demands for the Medium Population Projection - City of Guelph

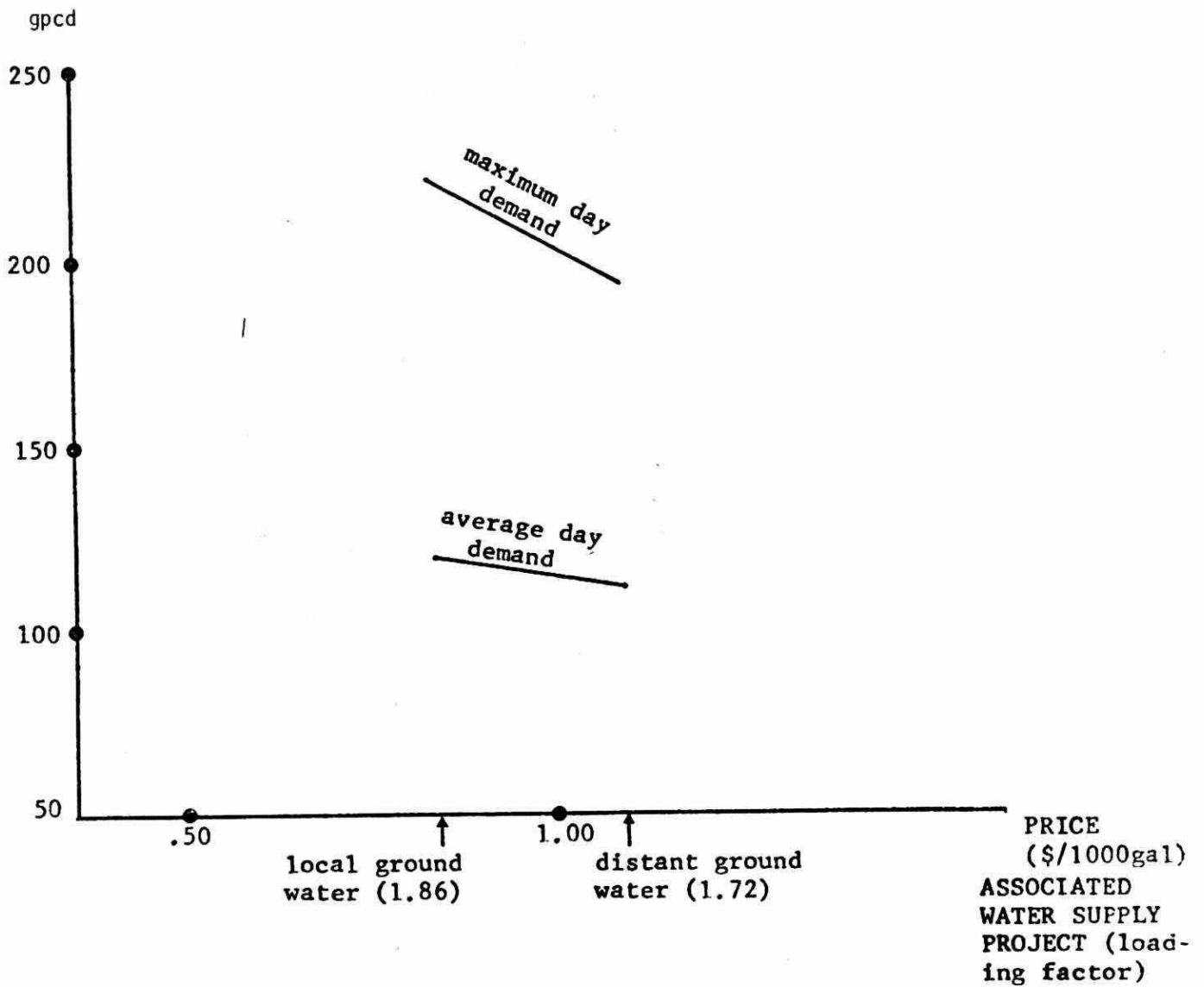
| Year                                    | Total Pumpage (mgd) |             | Loading<br>Factor | Average Day<br>Per Capita<br>Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|-------------------|---------------------------------------------|
|                                         | Average Day         | Maximum Day |                   |                                             |
| Base Case - Fixed Housing Mix           |                     |             |                   |                                             |
| 1981                                    | 10.28               | 18.38       | 1.79              | 129.0                                       |
| 2001                                    | 15.77               | 27.10       | 1.72              | 134.3                                       |
| 2031                                    | 28.19               | 46.11       | 1.64              | 133.5                                       |
| Base Case - Changing Housing Mix        |                     |             |                   |                                             |
| 1981                                    | 10.28               | 18.34       | 1.78              | 129.0                                       |
| 2001                                    | 15.76               | 26.77       | 1.70              | 134.2                                       |
| 2031                                    | 28.15               | 45.44       | 1.61              | 133.4                                       |
| Water Conservation Case - Low Response  |                     |             |                   |                                             |
| 1981                                    | 9.44                | 16.20       | 1.72              | 118.4                                       |
| 2001                                    | 12.75               | 21.58       | 1.69              | 108.5                                       |
| 2031                                    | 20.04               | 33.36       | 1.66              | 94.9                                        |
| Water Conservation Case - High Response |                     |             |                   |                                             |
| 1981                                    | 8.62                | 15.07       | 1.75              | 108.2                                       |
| 2001                                    | 11.27               | 19.68       | 1.75              | 95.9                                        |
| 2031                                    | 17.22               | 29.91       | 1.74              | 81.5                                        |

TABLE 2.27

Future Water Demands for the High Population Projection - City of Guelph

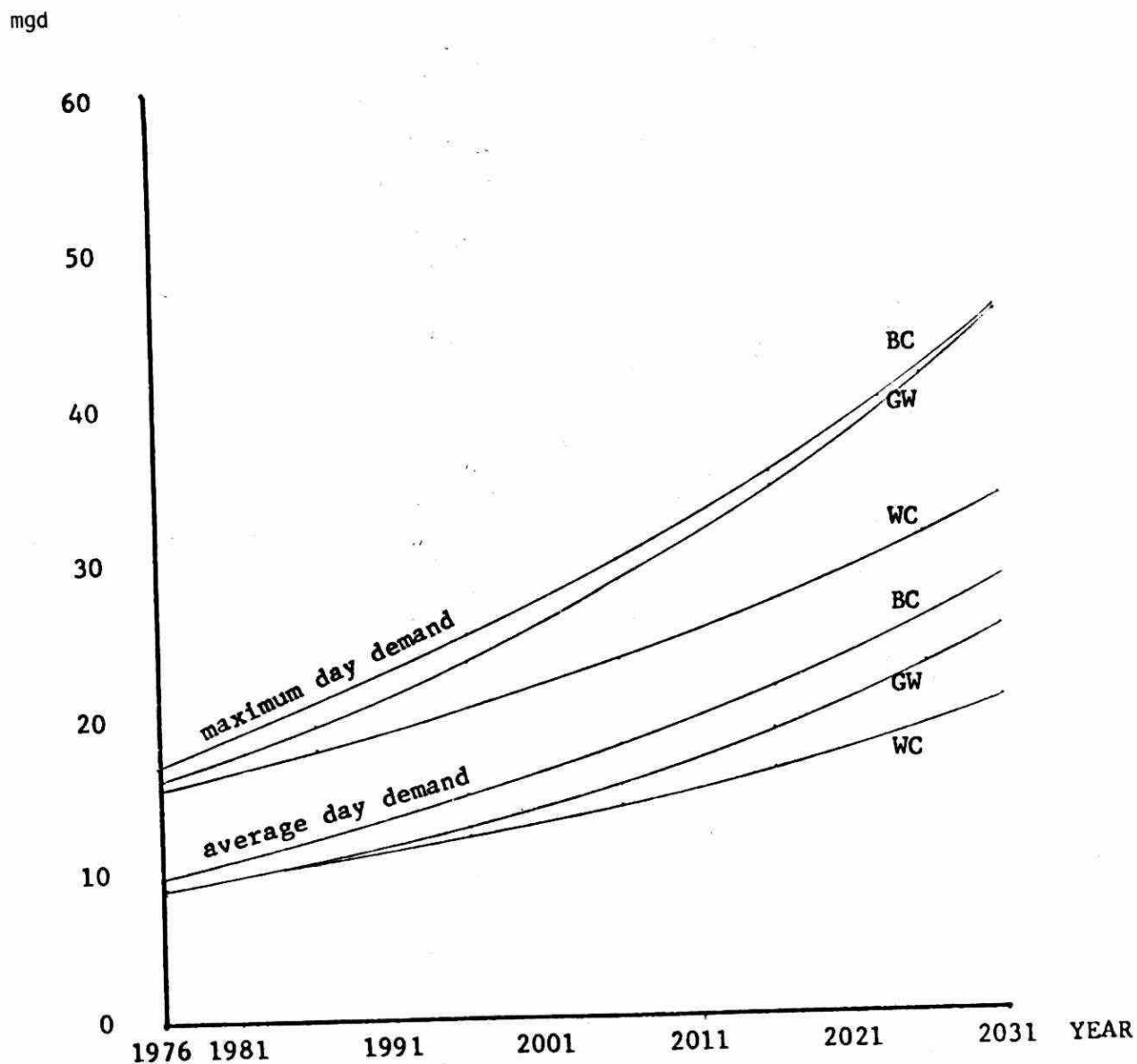
| Year                                    | Total Pumpage (mgd) |             | Loading<br>Factor | Average Day<br>Per Capita<br>Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|-------------------|---------------------------------------------|
|                                         | Average Day         | Maximum Day |                   |                                             |
| Base Case - Fixed Housing Mix           |                     |             |                   |                                             |
| 1981                                    | 10.53               | 18.81       | 1.79              | 129.0                                       |
| 2001                                    | 17.77               | 30.34       | 1.71              | 134.2                                       |
| 2031                                    | 36.72               | 59.08       | 1.61              | 133.2                                       |
| Base Case - Changing Housing Mix        |                     |             |                   |                                             |
| 1981                                    | 10.53               | 18.77       | 1.78              | 129.0                                       |
| 2001                                    | 17.76               | 29.95       | 1.69              | 134.0                                       |
| 2031                                    | 36.67               | 58.13       | 1.59              | 133.0                                       |
| Water Conservation Case - Low Response  |                     |             |                   |                                             |
| 1981                                    | 9.58                | 16.48       | 1.72              | 117.4                                       |
| 2001                                    | 13.92               | 23.60       | 1.69              | 105.1                                       |
| 2031                                    | 25.05               | 41.36       | 1.65              | 90.9                                        |
| Water Conservation Case - High Response |                     |             |                   |                                             |
| 1981                                    | 8.74                | 15.31       | 1.75              | 107.1                                       |
| 2001                                    | 12.23               | 21.45       | 1.75              | 92.3                                        |
| 2031                                    | 21.30               | 36.85       | 1.73              | 77.3                                        |

Figure 2.11 Impact of Price on Per Capita Consumption Rates  
in the City of Guelph as Supply Costs Increase



NOTE: - A flat rate price structure is assumed. Per capita consumption rates were not significantly affected by the level of population growth unless project costs varied with predicted growth rates.

Figure 2.12 Comparison of Water Demand Projections Using Medium Population Projections for the City of Guelph



LEGEND

- BC - Base case with changing housing mix
- GW - Pricing based on new ground water
- WC - Water conservation, low response

The various projections are compared in Figure 2.12. The base case projection depicts the highest consumption. The pricing projection incorporates only local ground water and some recharge from the Eramosa River so that unit prices do not change. This projection generates consumption rates lower than the base case projection because of the use of a flat rate price instead of the actual increasing block rate (Table 2.28). If circumstances do not change dramatically, then the base case projection is a reasonable estimate of water demand for the City of Guelph.

#### 2.2.1.4 Water Demand Projections for the City of Brantford

In some key respects, Brantford's water supply system differs from systems in other basin cities. It is the only city relying on treated surface water extracted from the Grand River. Since the supply system is not limited by the need to go a great distance to secure an adequate volume of water, capacity is limited primarily by the size of the treatment plant. Brantford has the greatest concentration of water intensive industries in the basin while city residents enjoy the lowest water price in the basin because of the absence of a unit sewer surcharge on small meters. Consequently, per capita consumption rates in Brantford are among the highest observed within the basin.

As was indicated for the other cities, population is a principal determinant of water demand while housing mix is of little consequence. Per capita use increases as family size falls because of the proportionately greater number of households in the City (Tables 2.29 to 2.31 and Figure 2.13).

The water conservation projections have a considerable impact on consumption in Brantford. This is a result of the current high level of losses and the heavy industrial use. The low response case reduces average day demand by 14% to 21% and maximum day demand by 16% to 20%. The high response case impacts are respectively 21% to 28% and 21% to 26%.

The rate structure analysis generates some anomalous results because of the low rate on the first block covering residential use. For each of the new

TABLE 2.28

Impact of New Rate Structures on Water Consumption - City of Guelph, 1978

| Rate<br>Structure                                  | Existing<br>Increasing<br>Block | Flat Rate | Increasing<br>Block | Seasonal<br>Surcharge | Excess<br>Use |
|----------------------------------------------------|---------------------------------|-----------|---------------------|-----------------------|---------------|
| <u>Prices Charged<sup>1</sup> (\$/1,000 gal):</u>  |                                 |           |                     |                       |               |
| First block<br>(0-50,000 gal/mo)                   | .94                             | .84       | .68                 | .61                   | .83           |
| Second block<br>(50,000-300,000 gal/mo)            | .77                             | .84       | .95                 | .61                   | .83           |
| Third block<br>(300,000-12x10 <sup>6</sup> gal/mo) | .60                             | .84       | 1.22                | .61                   | .83           |
| Summer Rate                                        | N/A                             | N/A       | N/A                 | 1.51                  | 2.42          |
| <u>Average Day Pumpage:</u>                        |                                 |           |                     |                       |               |
| Total (mgd)                                        | 9.38                            | 8.69      | 8.54                | 8.70                  | 8.50          |
| Per capita (gpcd)                                  | 131                             | 122       | 120                 | 122                   | 119           |
| <u>Maximum Day Pumpage (mgd):</u>                  | 15.94                           | 15.75     | 16.66               | 13.49                 | 11.99         |
| Loading Factor                                     | 1.70                            | 1.81      | 1.95                | 1.55                  | 1.41          |

<sup>1</sup>Prices include sewer surcharge. \$.43/1,000 gal is charged on consumption above 12x10<sup>6</sup> gal per month under existing rates. Few customers are found in this block.

N/A - Not applicable.

TABLE 2.29

## Future Water Demands for the Low Population Projection - City of Brantford

| Year                                    | Total Pumpage (mgd) |             | Loading<br>Factor | Average Day<br>Per Capita<br>Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|-------------------|---------------------------------------------|
|                                         | Average Day         | Maximum Day |                   |                                             |
| Base Case - Fixed Housing Mix           |                     |             |                   |                                             |
| 1981                                    | 9.45                | 16.86       | 1.78              | 134.4                                       |
| 2001                                    | 11.75               | 20.64       | 1.76              | 136.9                                       |
| 2031                                    | 15.79               | 27.05       | 1.71              | 136.5                                       |
| Base Case - Changing Housing Mix        |                     |             |                   |                                             |
| 1981                                    | 9.45                | 16.85       | 1.78              | 134.4                                       |
| 2001                                    | 11.73               | 20.36       | 1.74              | 136.7                                       |
| 2031                                    | 15.76               | 26.69       | 1.69              | 136.3                                       |
| Water Conservation Case - Low Response  |                     |             |                   |                                             |
| 1981                                    | 8.87                | 15.13       | 1.71              | 126.1                                       |
| 2001                                    | 10.06               | 17.21       | 1.71              | 117.2                                       |
| 2031                                    | 12.06               | 20.91       | 1.73              | 104.3                                       |
| Water Conservation Case - High Response |                     |             |                   |                                             |
| 1981                                    | 8.31                | 14.27       | 1.72              | 118.1                                       |
| 2001                                    | 9.27                | 16.09       | 1.74              | 108.0                                       |

TABLE 2.30

## Future Water Demands for the Medium Population Projection - City of Brantford

| Year                                    | Total Pumpage (mgd) |             | Loading<br>Factor | Average Day<br>Per Capita<br>Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|-------------------|---------------------------------------------|
|                                         | Average Day         | Maximum Day |                   |                                             |
| Base Case - Fixed Housing Mix           |                     |             |                   |                                             |
| 1981                                    | 9.65                | 17.20       | 1.78              | 134.4                                       |
| 2001                                    | 13.00               | 22.72       | 1.75              | 136.8                                       |
| 2031                                    | 19.71               | 33.31       | 1.69              | 136.3                                       |
| Base Case - Changing Housing Mix        |                     |             |                   |                                             |
| 1981                                    | 9.65                | 17.19       | 1.78              | 134.4                                       |
| 2001                                    | 12.98               | 22.43       | 1.73              | 136.6                                       |
| 2031                                    | 19.67               | 32.83       | 1.67              | 136.1                                       |
| Water Conservation Case - Low Response  |                     |             |                   |                                             |
| 1981                                    | 8.97                | 15.33       | 1.71              | 124.9                                       |
| 2001                                    | 10.68               | 18.43       | 1.73              | 112.4                                       |
| 2031                                    | 14.00               | 24.53       | 1.75              | 96.9                                        |
| Water Conservation Case - High Response |                     |             |                   |                                             |
| 1981                                    | 8.39                | 14.46       | 1.72              | 116.9                                       |
| 2001                                    | 9.78                | 17.17       | 1.75              | 103.0                                       |
| 2031                                    | 12.54               | 22.57       | 1.80              | 86.8                                        |

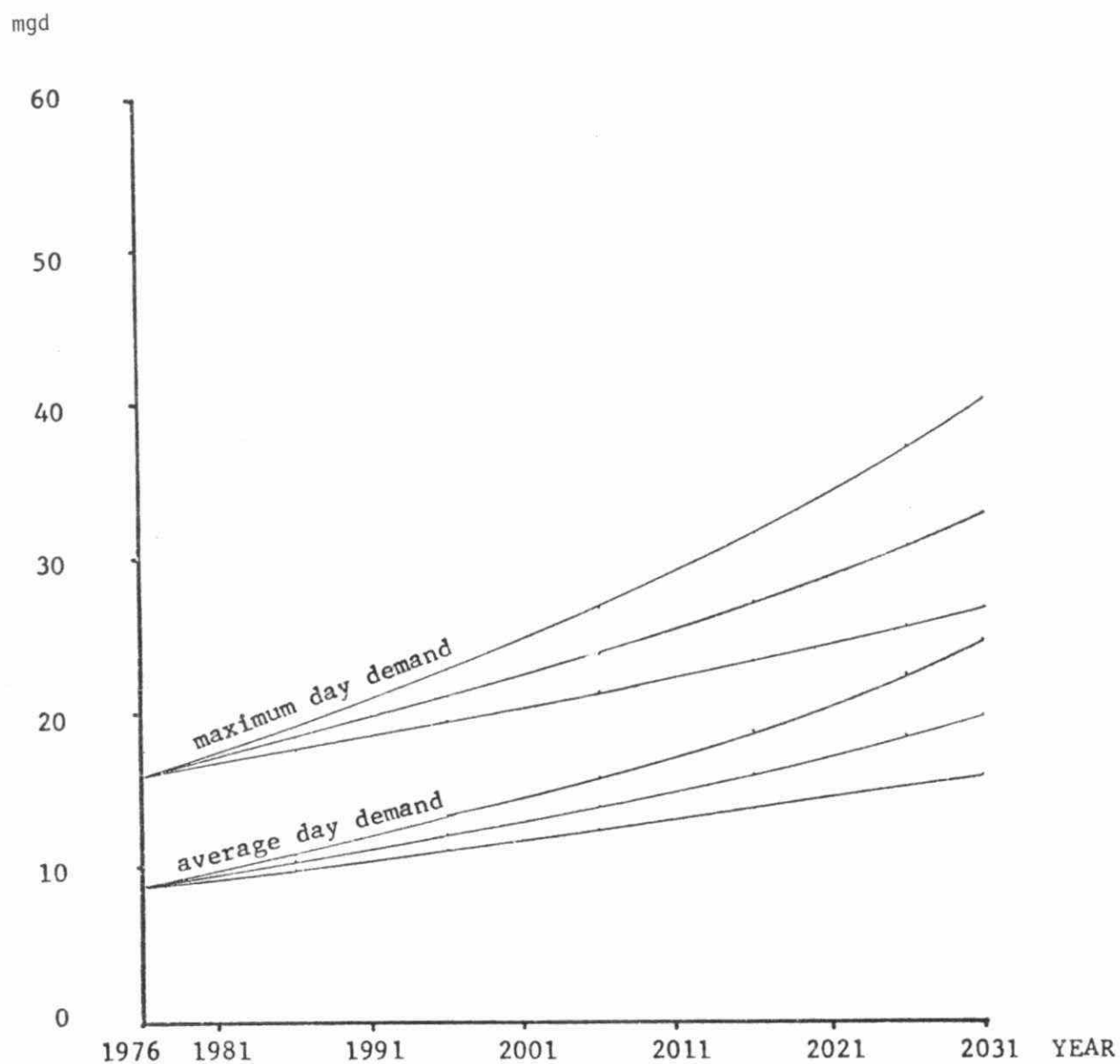


TABLE 2.31

## Future Water Demands for the High Population Projection - City of Brantford

| Year                                    | Total Pumpage (mgd) |             | Loading<br>Factor | Average Day<br>Per Capita<br>Pumpage (gpcd) |
|-----------------------------------------|---------------------|-------------|-------------------|---------------------------------------------|
|                                         | Average Day         | Maximum Day |                   |                                             |
| Base Case - Fixed Housing Mix           |                     |             |                   |                                             |
| 1981                                    | 9.84                | 17.54       | 1.78              | 134.4                                       |
| 2001                                    | 14.37               | 24.99       | 1.74              | 136.8                                       |
| 2031                                    | 24.58               | 41.02       | 1.67              | 136.2                                       |
| Base Case - Changing Housing Mix        |                     |             |                   |                                             |
| 1981                                    | 9.84                | 17.53       | 1.78              | 134.4                                       |
| 2001                                    | 14.35               | 24.66       | 1.72              | 136.5                                       |
| 2031                                    | 24.53               | 40.39       | 1.65              | 135.9                                       |
| Water Conservation Case - Low Response  |                     |             |                   |                                             |
| 1981                                    | 9.06                | 15.54       | 1.71              | 123.7                                       |
| 2001                                    | 11.36               | 19.76       | 1.74              | 108.1                                       |
| 2031                                    | 16.42               | 28.96       | 1.76              | 91.0                                        |
| Water Conservation Case - High Response |                     |             |                   |                                             |
| 1981                                    | 8.47                | 14.64       | 1.73              | 115.6                                       |
| 2001                                    | 10.35               | 18.36       | 1.77              | 98.5                                        |
| 2031                                    | 14.54               | 26.49       | 1.82              | 80.6                                        |

Figure 2.13 Base Case Projections with Changing Housing Mix Using Low, Medium and High Population Projections for the City of Brantford



LEGEND

- L - Low population projections
- M - Medium population projections
- H - High population projections

rate structures that were tested, the price to households falls because water sales revenue are assumed to remain constant. For the flat rate and increasing block rate schedules, maximum day use increases 11% to 39%. The seasonal surcharge results in little overall change while the excess use rate drops maximum day use by 13%. Per capita consumption changes little with each new rate (Table 2.32).

Only two supply projects are considered for Brantford; maintenance and expansion of the existing river water treatment plant or replacement of this system with water from the Lake Erie pipeline. Price increases associated with the pipeline have a dramatic impact on maximum day demand as can be seen in Figure 2.14.

Results of the base case and river water pricing projections are virtually the same as shown in Figure 2.15 because no price increases are foreseen in the pricing projection. The low response water conservation projection and the Lake Erie pipeline pricing projections are both below the base case projection and are very similar. If the lake pipeline is not used, then the higher projections are probably more realistic since there is little motivation for water conservation.

TABLE 2.32

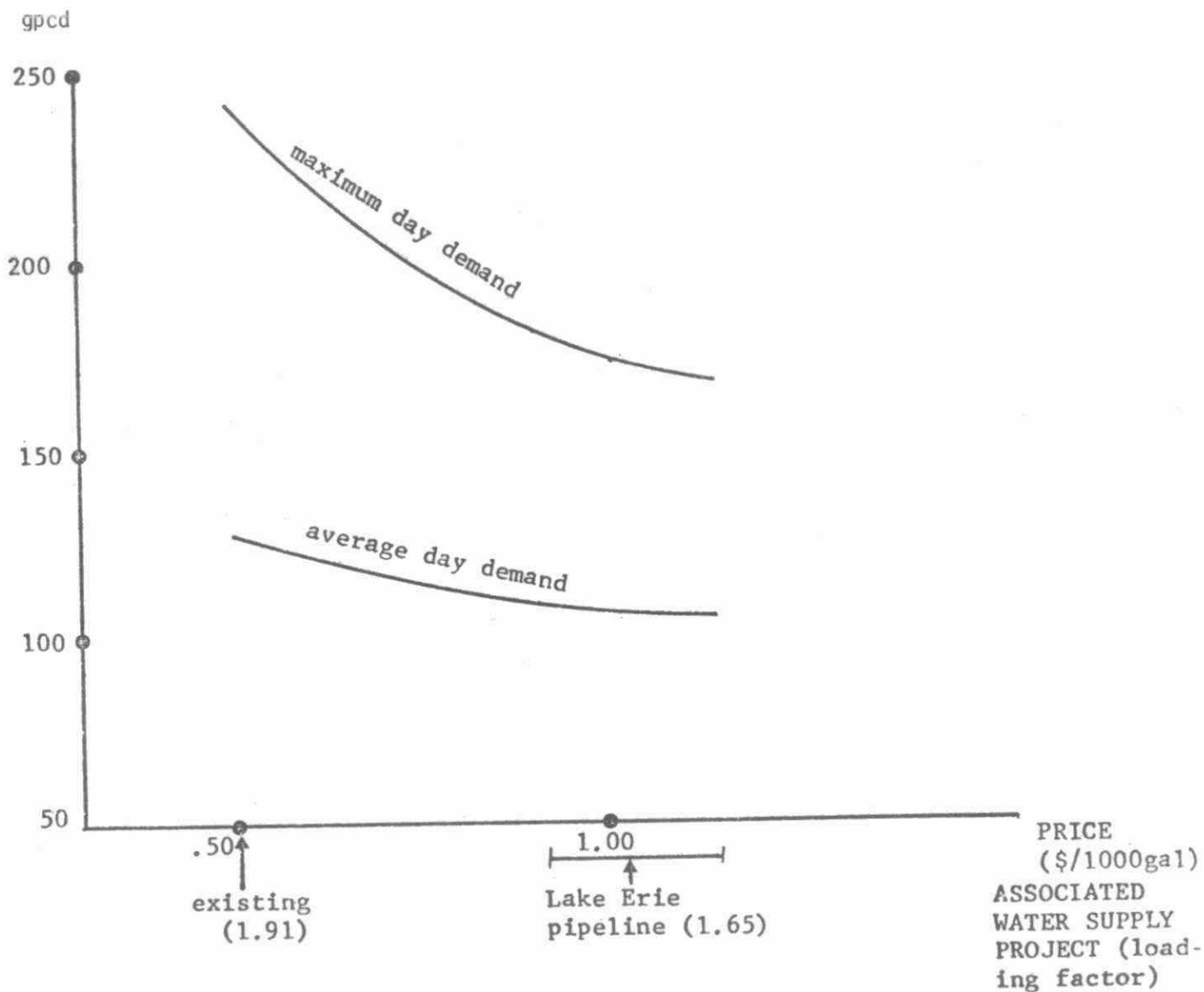
Impact of New Rate Structures on Water Consumption - City of Brantford, 1978

| Rate Structure                                    | Existing Increasing Block | Flat Rate | Increasing Block | Seasonal Surcharge | Excess Use |
|---------------------------------------------------|---------------------------|-----------|------------------|--------------------|------------|
| <u>Prices Charged<sup>1</sup> (\$/1,000 gal):</u> |                           |           |                  |                    |            |
| First block<br>(0-44,000 gal/mo)                  | .55                       | .49       | .26              | .38                | .48        |
| Second block<br>(44,000-374,000 gal/mo)           | .78                       | .49       | .60              | .38                | .48        |
| Third block<br>(>374,000 gal/mo)                  | .61                       | .49       | .78              | .38                | .48        |
| Summer Rate                                       | N/A                       | N/A       | N/A              | .80                | 1.18       |
| <u>Average day Pumpage:</u>                       |                           |           |                  |                    |            |
| Total (mgd)                                       | 9.94                      | 9.85      | 10.10            | 9.74               | 9.52       |
| Per capita (gpcd)                                 | 143                       | 143       | 146              | 141                | 138        |
| <u>Maximum Day Pumpage (mgd):</u>                 | 16.00                     | 17.80     | 22.25            | 15.54              | 14.02      |
| Loading Factor                                    | 1.61                      | 1.81      | 2.20             | 1.59               | 1.47       |

<sup>1</sup>Prices include sewer surcharge. Note that no sewage surcharge is levied on the first block.

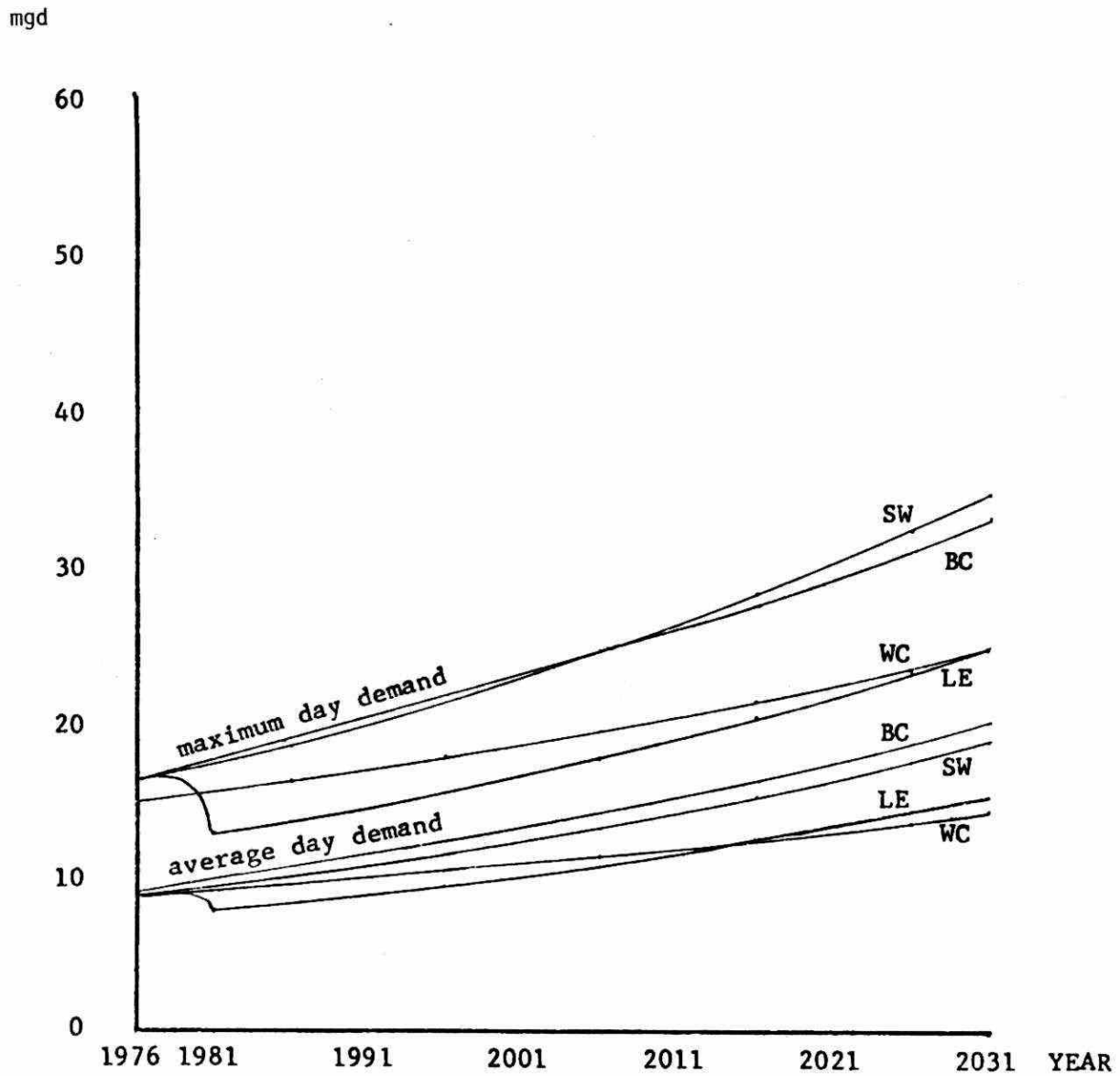
N/A - Not applicable.

Figure 2.14 Impact of Price on Per Capita Consumption Rates in the City of Brantford as Supply Costs Increase



NOTE: - A flat rate price structure is assumed. Per capita consumption rates were not significantly affected by the level of population growth unless project costs varied with predicted growth rates.

Figure 2.15 Comparison of Water Demand Projections Using Medium Population Projections for the City of Brantford



LEGEND

- BC - Base case with changing housing mix
- SW - Pricing based on expanded surface water source
- LE - Pricing based on Lake Erie pipeline
- WC - Water conservation, low response

#### 2.2.1.5 Summary of Municipal Water Demand Projections for the Major Urban Centres Within the Grand River Basin

Three basic approaches were used in projecting future municipal water demand for the five major urban centres within the Grand River basin. The first approach predicted demand by using existing consumption rates, the second involved assumptions about new conservation measures that could be implemented to reduce consumption, the third modified existing consumption rates to reflect changing water prices.

For summary purposes, 7 projections based on these three approaches were used, the techniques of which are described in Table 2.33. A range in the water consumption rates for the years 2001 and 2031 was produced following these techniques (Table 2.34).

Base case projections for the Cities of Kitchener, Waterloo and Cambridge show per capita rates increasing by up to 5%. This is due to the use of fixed household consumption rates rather than per capita consumption rates to forecast residential consumption.

Forecasts 4 to 7 show average day per capita demand falling by 1% to 30%. The smaller reductions are more likely for Kitchener and Waterloo since these communities have already implemented water conservation programs, a fact not accounted for in these projections. Potential reductions in Cambridge depend critically on the future level of losses (10% of pumpage in 1978). The consumption levels predicted by projection 5 are conceivable in that the associated consumption rates have already been observed in Kitchener and Waterloo.

Consumption rates for Brantford are shown to decrease in all but one of the projections. The high level of consumption in the community can be attributed primarily to industry and losses. Potential savings depend on the scope for adjustment in these two areas. So long as the source of supply, the river, is not considered to be in jeopardy, one may well question the need to reduce consumption in this city. The only real motivation for conservation is financial. In light of this, the base case projection is probably realistic.

TABLE 2.33

Description of Water Demand Forecasting Methods for the Major  
Urban Centres Within the Grand River Basin

| No. | Main Feature                                                                                                                                | Population<br>Base | Level of Aggregation<br>of Demand                                                                                  | Source                      |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------------------------------------------------------------------------------------------------------|-----------------------------|
| 1   | Base Case - demand pro-<br>rated using existing<br>consumption rates                                                                        | LOW                | 6 categories treated<br>separately<br>-apartment, residential,<br>commercial, industrial,<br>institutional, losses | Section 2 of<br>this report |
| 2   | Base Case - as in Test 1                                                                                                                    | MEDIUM             | as in Test 1                                                                                                       | as in Test 1                |
| 3   | Base Case - as in Test 1                                                                                                                    | HIGH               | as in Test 1                                                                                                       | as in Test 1                |
| 4   | Price sensitive (high) -<br>empirically derived demand<br>curves used to predict<br>response of consumption to<br>anticipated price changes | MEDIUM             | forecast based on<br>aggregate community<br>demand                                                                 | Fortin (1980)               |
| 5   | Price sensitive (low) - as<br>in Test 4                                                                                                     | MEDIUM             | as in Test 1                                                                                                       | as in Test 1                |
| 6   | Water conservation (high) -<br>a water conservation<br>program is implemented,<br>moderate residential<br>response is assumed               | MEDIUM             | as in Test 1                                                                                                       | as in Test 1                |
| 7   | Water conservation (low) -<br>a water conservation<br>program is implemented,<br>maximum residential<br>response is assumed                 | MEDIUM             | as in Test 1                                                                                                       | as in Test 1                |



TABLE 2.34

Estimated Future Consumption Rates for Large Urban Centres, 2001 and 2031

|                                                                   | 2001                                  |                        |                        |                                      |                        |                                         |                        |  | 2031                                  |                        |                        |                                      |                        |                                         |                       |  |
|-------------------------------------------------------------------|---------------------------------------|------------------------|------------------------|--------------------------------------|------------------------|-----------------------------------------|------------------------|--|---------------------------------------|------------------------|------------------------|--------------------------------------|------------------------|-----------------------------------------|-----------------------|--|
| Community<br>- Demand<br>Component                                | Base Case - 1976<br>Consumption Rates |                        |                        | Price Sensitive<br>Medium Population |                        | Water Conservation<br>Medium Population |                        |  | Base Case - 1976<br>Consumption Rates |                        |                        | Price Sensitive<br>Medium Population |                        | Water Conservation<br>Medium Population |                       |  |
|                                                                   | Low<br>Population                     | Medium<br>Population   | High<br>Population     | High Demand<br>Curve                 | Low Demand<br>Curve    | Moderate<br>Response                    | Maximum<br>Response    |  | Low<br>Population                     | Medium<br>Population   | High<br>Population     | High Demand<br>Curve                 | Low Demand<br>Curve    | Moderate<br>Response                    | Maximum<br>Response   |  |
| Waterloo<br>-Ave. Day<br>gpcd<br>mgd<br>-Max. Day<br>gpcd<br>mgd  | 105<br>9<br>160<br>14                 | 105<br>10<br>159<br>15 | 105<br>10<br>159<br>15 | 96<br>8<br>154<br>13                 | 88<br>18<br>132<br>12  | 94<br>9<br>138<br>13                    | 82<br>8<br>124<br>11   |  | 105<br>10<br>158<br>15                | 105<br>14<br>153<br>20 | 105<br>16<br>152<br>23 | 100<br>13<br>160<br>21               | 88<br>11<br>131<br>17  | 92<br>12<br>132<br>17                   | 79<br>10<br>117<br>15 |  |
| Kitchener<br>-Ave. Day<br>gpcd<br>mgd<br>-Max. Day<br>gpcd<br>mgd | 108<br>23<br>159<br>33                | 108<br>24<br>159<br>35 | 108<br>25<br>158<br>37 | 98<br>21<br>157<br>34                | 92<br>21<br>138<br>30  | 97<br>22<br>140<br>31                   | 86<br>19<br>127<br>28  |  | 108<br>25<br>158<br>36                | 108<br>34<br>153<br>49 | 107<br>39<br>151<br>56 | 102<br>32<br>163<br>51               | 93<br>30<br>139<br>43  | 94<br>30<br>132<br>42                   | 83<br>26<br>119<br>38 |  |
| Guelph<br>-Ave. Day<br>gpcd<br>mgd<br>-Max. Day<br>gpcd<br>mgd    | 134<br>12<br>231<br>21                | 134<br>16<br>228<br>28 | 134<br>18<br>226<br>30 | 134<br>15<br>214<br>24               | 119<br>14<br>225<br>26 | 109<br>13<br>183<br>22                  | 96<br>11<br>168<br>20  |  | 134<br>17<br>225<br>28                | 133<br>28<br>215<br>45 | 133<br>37<br>211<br>58 | 143<br>29<br>229<br>46               | 119<br>25<br>213<br>45 | 91<br>25<br>150<br>41                   | 77<br>21<br>133<br>37 |  |
| Brantford<br>-Ave. Day<br>gpcd<br>mgd<br>-Max. Day<br>gpcd<br>mgd | 137<br>12<br>238<br>20                | 137<br>13<br>236<br>22 | 137<br>14<br>235<br>25 | 143<br>13<br>229<br>21               | 128<br>12<br>243<br>23 | 112<br>11<br>194<br>18                  | 103<br>10<br>180<br>17 |  | 136<br>16<br>230<br>27                | 136<br>20<br>227<br>33 | 136<br>25<br>224<br>40 | 150<br>21<br>240<br>34               | 128<br>18<br>242<br>35 | 97<br>14<br>170<br>25                   | 87<br>13<br>156<br>23 |  |
| Cambridge<br>-Ave. Day<br>gpcd<br>mgd<br>-Max. Day<br>gpcd<br>mgd | 121<br>14<br>172<br>20                | 121<br>15<br>172<br>21 | 121<br>18<br>170<br>22 | 111<br>13<br>178<br>21               | 102<br>13<br>153<br>19 | 100<br>12<br>140<br>18                  | 87<br>11<br>127<br>16  |  | 121<br>16<br>172<br>22                | 121<br>22<br>167<br>30 | 121<br>25<br>166<br>34 | 114<br>20<br>182<br>32               | 102<br>18<br>153<br>27 | 93<br>17<br>130<br>23                   | 80<br>14<br>116<br>21 |  |

In Guelph, institutional consumption and losses are both high. Household consumption rates also appear to be high. The first four projections show some increase in per capita consumption primarily due to assumptions about family size or industrial growth. Recent rate structure modifications may have already produced some of the savings shown in projections 5, 6 and 7.

Generalizations cannot be made about these projections since consumption characteristics and supply circumstances vary among municipalities. Assuming that the 1978 data is representative, water losses in the municipal system seem to be prominent in three cities: Cambridge, Guelph and Brantford. However, the observed losses are not likely to occur in new distribution systems. This factor will depress future per capita consumption rates. Beyond this, financial and engineering considerations will largely determine the need for and desire for reductions in demand. The radical changes forecast by projection 7 are improbable.

#### 2.2.2 Smaller Urban Centres

To estimate a probable level and range of per capita consumption rates in small communities, a statistical analysis of water consumption in small Ontario communities was undertaken. Data for this analysis were taken from survey information published in the National Inventory of Municipal Waterworks and Wastewater Systems in Canada, 1977 (Canada Supply and Services, 1978). Table 2.35 summarizes the results of this analysis. Measures of standard deviation for all the tests indicate that consumption rates vary widely. Sample data for both average day consumption and maximum day consumption are skewed to the lower end with modal values lying below mean values. Seventy-five percent of average day observations lie between 50 and 175 gpcd (227.28 and 795.47 L/capita d) while 77% of maximum day observations lie between 100 and 350 gpcd (454.56 and 1 590.95 L/capita d).

Consumption characteristics of smaller Grand River basin communities are described in Table 2.36. Mean average day and maximum day figures are close to provincial levels, while the individual figures for each community are well within a "normal" range with the possible exceptions of Elmira and Dunnville. Both of these communities have prominent water consuming

TABLE 2.35

Analysis of Daily Per Capita Water Consumption Rates in  
Small Ontario Communities

| Sample No.                                                                | Average Day Per Capita Demand |                    |                  | Maximum Day Per Capita Demand |                    |                  |
|---------------------------------------------------------------------------|-------------------------------|--------------------|------------------|-------------------------------|--------------------|------------------|
|                                                                           | 1                             | 2                  | 3                | 4                             | 5                  | 6                |
| Population Range                                                          | 1,000-<br>20,000              | 1,000-<br>3,000    | 3,000-<br>10,000 | 1,000-<br>20,000              | 1,000-<br>3,000    | 3,000-<br>10,000 |
| Sample Size                                                               | 215                           | 110                | 82               | 189                           | 96                 | 72               |
| Mean                                                                      | 132                           | 121                | 142              | 247                           | 232                | 265              |
| Mode                                                                      | 113                           | 113                | 113              | 175                           | 175                | 175              |
| Standard<br>Deviation                                                     | 75                            | 83                 | 63               | 127                           | 142                | 111              |
| Maximum<br>Observation                                                    | 548                           | 548                | 390              | 882                           | 882                | 681              |
| Minimum<br>Observation                                                    | 24                            | 24                 | 40               | 27                            | 27                 | 79               |
| Simple Correlation<br>Between Population<br>and Per Capita<br>Consumption | .079                          | -.075              | .029             | .048                          | -.124              | -.033            |
| T-Tests Comparing Mean Values of Daily Per Capita Consumption Rates       |                               |                    |                  |                               |                    |                  |
| Sample No.                                                                | (2)                           | (3)                | Sample No.       | (5)                           | (6)                |                  |
| (1)                                                                       | 1.202                         | 1.068              | (4)              | .902                          | 1.054              |                  |
| (2)                                                                       |                               | 1.906 <sup>1</sup> | (5)              |                               | 1.623 <sup>1</sup> |                  |

<sup>1</sup>Significant at 90% level.

TABLE 2.36

Municipal Water Supply Data for Smaller Urban Centres  
Within the Grand River Basin

| Municipality | Consumption (gpcd)<br>Ave. Day/Max. Day | Loading<br>Factor | Reference<br>Year(s) | Population<br>In the Basin | Water Rate<br>Structure                         |
|--------------|-----------------------------------------|-------------------|----------------------|----------------------------|-------------------------------------------------|
| Caledonia    | 92/191                                  | 2.08              | 1976-1978            | 3,669                      | flat rate                                       |
| Cayuga       | 121/215                                 | 1.77              | 1976-1978            | 1,143                      | flat rate                                       |
| Dundalk      | 87/152                                  | 1.75              | 1975-1979            | 1,130                      | no information                                  |
| Dunnville*   | 192/428                                 | 2.23              | 1976-1978            | 5,430                      | declining block rate                            |
| Elmira*      | 236/357                                 | 1.51              | 1976, 1978-79        | 7,034                      | declining block rate                            |
| Elora        | 105/152                                 | 1.45              | 1976, 1978-79        | 2,474                      | no information                                  |
| Fergus       | 104/141                                 | 1.36              | 1976, 1978-79        | 5,967                      | domestic-fixed charge,<br>other-declining block |
| New Hamburg  | 93/174                                  | 1.87              | 1976-1979            | 3,628                      | declining block                                 |
| Paris        | 128/215                                 | 1.68              | 1978-1979            | 6,691                      | flat rate                                       |
| Average      | 104/177<br>129/225                      | 1.70<br>1.74      |                      | 4,129<br>4,129             |                                                 |

\*Both these communities have large industrial users that cause per capita consumption rates to be high.

Sources: Ministry of the Environment, Annual Pumping Reports (1976-1979)  
Veale (1980 b)

manufacturers on their systems. The Dunnville manufacturer is a food processor with a highly variable seasonal rate of consumption; this accounts for the high loading factor in that community. When these two towns are omitted from the computation, mean average day and maximum day consumption rates are 104 and 177 gpcd (472.74 and 804.56 L/capita-d) respectively.

Consumption data was either unreliable or unavailable for Arthur, Drayton, Ayr, Grand Valley, Wellesley and Milverton. Many of these communities still rely on private wells for their water supplies. To project demand for these communities, mean consumption rates estimated for small communities other than Dunnville and Elmira were used. Projections for all communities are given in Table 2.37.

### 2.3 IMPLICATIONS OF MUNICIPAL WATER DEMAND PROJECTIONS

When comparing possible future water consumption figures generated by the preceding analyses to the available water source capacities of each municipality on a municipal water supply system, possible water shortage areas can be identified.

Table 2.1 indicates the 1979 water source capacity for municipalities on a municipal water supply system. Tables 2.38 and 2.39 show average and maximum daily water demands respectively, for the 5 major urban centres based on the 7 projections selected. In municipalities where: (1) supply systems are designed to accommodate maximum day needs, (2) sufficient water storage is available, and (3) there is enough water available for continuous extraction to meet average day demand, water shortages will not be experienced.

By comparing average and maximum daily water demands to 1979 system capacities, it is evident that water shortages could be felt in all major cities (with the exception of Brantford where projected water demand should be met by water extracted from the Grand River), by the year 2031 if no conservation measures or new pricing structures were implemented. Additional water supplies will be necessary to meet demand before 2001 for the Cities of Kitchener and Waterloo. The time at which these new supplies

TABLE 2.37

Projections of Water Demand for Smaller  
Municipalities in the Grand River Basin

| Municipality                     | Year<br>1979 | 2001  |        |       | 2031  |        |       |
|----------------------------------|--------------|-------|--------|-------|-------|--------|-------|
|                                  |              | Low   | Medium | High  | Low   | Medium | High  |
| Average Day Demand (1,000's gpd) |              |       |        |       |       |        |       |
| Fergus                           | 621          | 885   | 1,158  | 1,371 | 1,204 | 2,372  | 3,329 |
| Paris                            | 856          | 1,024 | 1,126  | 1,214 | 1,102 | 1,398  | 1,686 |
| Caledonia                        | 338          | 598   | 897    | 1,196 | 1,196 | 1,456  | 1,716 |
| Dunnville                        | 1,043        | 1,364 | 1,380  | 1,467 | 1,833 | 2,012  | 2,320 |
| Elmira                           | 1,660        | 2,053 | 2,188  | 2,277 | 2,259 | 3,141  | 3,612 |
| New Hamburg                      | 337          | 422   | 449    | 468   | 464   | 645    | 742   |
| Elora                            | 260          | 401   | 467    | 561   | 675   | 945    | 1,362 |
| Cayuga                           | 138          | 145   | 224    | 302   | 302   | 368    | 434   |
| Ayr                              | 138          | 223   | 237    | 247   | 245   | 341    | 392   |
| Drayton                          | 85           | 108   | 123    | 157   | 146   | 192    | 329   |
| Dundalk                          | 98           | 136   | 161    | 182   | 195   | 291    | 382   |
| Grand Valley                     | 110          | 159   | 181    | 222   | 248   | 328    | 513   |
| Wellesley                        | 88           | 152   | 162    | 168   | 167   | 232    | 267   |
| Arthur                           | 169          | 212   | 229    | 246   | 263   | 324    | 384   |
| Milverton                        | 73           | 79    | 107    | 153   | 87    | 169    | 371   |
| Maximum Day Demand (1,000's gpd) |              |       |        |       |       |        |       |
| Fergus                           | 841          | 1,199 | 1,570  | 1,859 | 1,632 | 3,216  | 4,513 |
| Paris                            | 1,439        | 1,720 | 1,892  | 2,039 | 1,851 | 2,348  | 2,831 |
| Caledonia                        | 701          | 1,241 | 1,862  | 2,483 | 2,483 | 3,023  | 3,562 |
| Dunnville                        | 2,324        | 3,040 | 3,076  | 2,369 | 4,085 | 4,485  | 5,171 |
| Elmira                           | 2,511        | 3,106 | 3,310  | 3,444 | 3,418 | 4,751  | 5,465 |
| New Hamburg                      | 631          | 789   | 841    | 875   | 868   | 1,207  | 1,388 |
| Elora                            | 376          | 580   | 676    | 812   | 976   | 1,367  | 1,971 |
| Cayuga                           | 246          | 258   | 398    | 537   | 537   | 654    | 771   |
| Ayr                              | 236          | 379   | 404    | 421   | 417   | 580    | 667   |
| Drayton                          | 144          | 184   | 209    | 267   | 249   | 326    | 560   |
| Dundalk                          | 172          | 237   | 282    | 318   | 340   | 509    | 668   |
| Grand Valley                     | 188          | 271   | 308    | 377   | 422   | 558    | 873   |
| Wellesley                        | 149          | 259   | 276    | 287   | 285   | 396    | 455   |
| Arthur                           | 288          | 361   | 389    | 418   | 448   | 551    | 653   |
| Milverton                        | 124          | 134   | 182    | 260   | 147   | 288    | 631   |

TABLE 2.38

Additional Municipal Water Supply Necessary to Meet Average Day Projected Demand\*, 2001 and 2031  
(mgd)

| Community \ Water Demand Projections           | 2001           |                   |                 |                                   |                  |                                      |                  |  | 2031           |                   |                 |                                   |                  |                                      |                  |  |
|------------------------------------------------|----------------|-------------------|-----------------|-----------------------------------|------------------|--------------------------------------|------------------|--|----------------|-------------------|-----------------|-----------------------------------|------------------|--------------------------------------|------------------|--|
|                                                | Base Case      |                   |                 | Price Sensitive Medium Population |                  | Water Conservation Medium Population |                  |  | Base Case      |                   |                 | Price Sensitive Medium Population |                  | Water Conservation Medium Population |                  |  |
|                                                | Low Population | Medium Population | High Population | High Demand Curve                 | Low Demand Curve | Moderate Response                    | Maximum Response |  | Low Population | Medium Population | High Population | High Demand Curve                 | Low Demand Curve | Moderate Response                    | Maximum Response |  |
| Kitchener-Waterloo<br>System Capacity = 32.648 |                |                   |                 |                                   |                  |                                      |                  |  |                |                   |                 |                                   |                  |                                      |                  |  |
| Ave. Day Demand (1977) = 18.18                 | 31.63          | 33.70             | 35.07           | 30.65                             | 28.58            | 30.24                                | 26.69            |  | 34.80          | 48.37             | 55.27           | 45.80                             | 41.34            | 42.18                                | 36.95            |  |
| Additional Supplies Needed                     | --             | .95               | 2.42            | --                                | --               | --                                   | --               |  | 2.15           | 15.73             | 22.62           | 13.15                             | 8.69             | 9.54                                 | 4.30             |  |
| Guelph<br>System Capacity = 25.81              |                |                   |                 |                                   |                  |                                      |                  |  |                |                   |                 |                                   |                  |                                      |                  |  |
| Ave. Day Demand (1977) = 9.50                  | 12.09          | 15.47             | 17.48           | 15.47                             | 13.74            | 12.58                                | 11.08            |  | 16.30          | 27.81             | 36.40           | 29.91                             | 24.89            | 19.03                                | 16.10            |  |
| Additional Supplies Needed                     | --             | --                | --              | --                                | --               | --                                   | --               |  | --             | 2.00              | 10.59           | 4.10                              | --               | --                                   | --               |  |
| Brantford<br>System Capacity = 17.50           |                |                   |                 |                                   |                  |                                      |                  |  |                |                   |                 |                                   |                  |                                      |                  |  |
| Ave. Day Demand 1977 = 9.67                    | 12.29          | 13.60             | 15.04           | 14.19                             | 12.70            | 11.11                                | 10.22            |  | 16.44          | 20.54             | 25.65           | 22.66                             | 19.33            | 14.65                                | 13.14            |  |
| Additional Supplies Needed                     | --             | --                | --              | --                                | --               | --                                   | --               |  | --             | 3.04              | 8.15            | 5.16                              | 1.93             | --                                   | --               |  |
| Cambridge<br>System Capacity = 16.99           |                |                   |                 |                                   |                  |                                      |                  |  |                |                   |                 |                                   |                  |                                      |                  |  |
| Ave. Day Demand (1977) = 8.58                  | 14.13          | 15.06             | 15.67           | 13.82                             | 12.70            | 12.45                                | 10.83            |  | 15.55          | 21.62             | 24.86           | 20.37                             | 18.22            | 16.62                                | 14.29            |  |
| Additional Supplies Needed                     | --             | --                | --              | --                                | --               | --                                   | --               |  | --             | 4.63              | 7.87            | 3.38                              | 1.23             | --                                   | --               |  |

\*Refers to supplies which would be necessary to meet demand after the 1979 Source capacity is fully utilized.

\*\*Demand for the City of Brantford is expected to be met wholly through extraction of river water.

TABLE 2.39

Additional Municipal Water Supply Necessary to Meet Projected Maximum Day Demand\*, 2001 and 2031  
(mgd)

| Community \ Water Demand Projections           | 2001           |                   |                 |                                   |                  |                                      |                  |  | 2031           |                   |                 |                                   |                  |                                      |                  |  |
|------------------------------------------------|----------------|-------------------|-----------------|-----------------------------------|------------------|--------------------------------------|------------------|--|----------------|-------------------|-----------------|-----------------------------------|------------------|--------------------------------------|------------------|--|
|                                                | Base Case      |                   |                 | Price Sensitive Medium Population |                  | Water Conservation Medium Population |                  |  | Base Case      |                   |                 | Price Sensitive Medium Population |                  | Water Conservation Medium Population |                  |  |
|                                                | Low Population | Medium Population | High Population | High Demand Curve                 | Low Demand Curve | Moderate Response                    | Maximum Response |  | Low Population | Medium Population | High Population | High Demand Curve                 | Low Demand Curve | Moderate Response                    | Maximum Response |  |
| Kitchener-Waterloo<br>System Capacity = 32.648 |                |                   |                 |                                   |                  |                                      |                  |  |                |                   |                 |                                   |                  |                                      |                  |  |
| Max. Day Demand (1977) = 29.08                 | 47.032         | 50.024            | 51.822          | 49.118                            | 42.864           | 43.862                               | 39.680           |  | 51.327         | 69.091            | 76.581          | 73.210                            | 61.711           | 59.608                               | 53.473           |  |
| Additional Supplies Needed                     | 14.384         | 17.376            | 19.174          | 16.470                            | 10.216           | 11.214                               | 7.032            |  | 18.679         | 36.443            | 43.933          | 40.562                            | 29.063           | 26.96                                | 20.825           |  |
| Guelph<br>System Capacity = 25.81              |                |                   |                 |                                   |                  |                                      |                  |  |                |                   |                 |                                   |                  |                                      |                  |  |
| Max. Day Demand (1977) = 13.10                 | 20.85          | 26.32             | 29.49           | 24.71                             | 25.98            | 21.13                                | 19.40            |  | 27.37          | 44.96             | 57.74           | 47.89                             | 44.55            | 31.37                                | 27.81            |  |
| Additional Supplies Needed                     | --             | .51               | 3.68            | --                                | .17              | --                                   | --               |  | 1.56           | 19.15             | 31.93           | 22.08                             | 18.74            | 5.56                                 | 2.00             |  |
| Brantford**<br>System Capacity = 17.50         |                |                   |                 |                                   |                  |                                      |                  |  |                |                   |                 |                                   |                  |                                      |                  |  |
| Max. Day Demand (1977) = 16.12                 | 21.34          | 23.42             | 25.80           | 22.73                             | 24.11            | 19.25                                | 17.86            |  | 27.80          | 34.29             | 42.24           | 36.25                             | 36.55            | 25.68                                | 23.56            |  |
| Additional Supplies Needed                     | 3.84           | 5.92              | 8.30            | 5.23                              | 6.61             | 1.75                                 | .33              |  | 10.3           | 16.79             | 24.74           | 18.75                             | 19.05            | 8.18                                 | 6.06             |  |
| Cambridge<br>System Capacity = 16.99           |                |                   |                 |                                   |                  |                                      |                  |  |                |                   |                 |                                   |                  |                                      |                  |  |
| Max. Day Demand (1977) = 12.87                 | 20.09          | 21.41             | 22.02           | 22.16                             | 19.04            | 17.43                                | 15.81            |  | 22.11          | 29.84             | 34.11           | 32.52                             | 27.34            | 23.23                                | 20.72            |  |
| Additional Supplies Needed                     | 3.10           | 4.42              | 5.03            | 5.17                              | 2.05             | .44                                  | --               |  | 5.12           | 12.85             | 17.12           | 15.53                             | 10.35            | 6.24                                 | 3.73             |  |

\*Refers to supplies which would be necessary to meet demand after the 1979 Source capacity is fully utilized.

\*\*Demand for the City of Brantford is expected to be met wholly through extraction of river water.



will be required is dependent on population growth and water conservation practices. The City of Guelph will require new water supplies by 2031 if population growth equals the medium or high population projections and no conservation methods are adopted.

Water demand in the smaller municipalities of the watershed was estimated using mean average day and maximum day consumption rates of 104 and 177 gpcd (472.74 and 804.56 L/capita·d) respectively and applying these rates to future projected populations. Two communities may experience water shortages by the year 2031. Elora is expected to experience shortages if the projected low population were reached while Fergus is expected to require more supplies if the medium population projection were realized.

### 3. INDUSTRIAL WATER DEMAND FROM PRIVATE WATER SOURCES

#### 3.1 EXISTING WATER USE

Many industries within the Grand River basin obtain water from private surface or ground-water sources. Of 65 industries which obtained approval from the Ontario Ministry of the Environment between 1963-1980, 55 or 85% were allowed to extract ground water from wells or dugout ponds. Most of the remaining industries were associated with the mineral aggregate business and permitted to use surface water for washing and dust control (Appendix D).

To determine whether or not actual water demand by industries approximates permitted use, a sample telephone survey of the 75% of the industries using private water sources in the Middle Grand River sector (the sector of largest industrial water consumption) was conducted during the fall, 1980. Most industries reported that actual water use approximated that which was authorized by permit.

To estimate actual total water demand, the daily rates recorded in the water taking permits were multiplied by the recorded number of days the industry extracted water. These estimates were adjusted to account for industries no longer in operation or using private water supply systems. Where daily and yearly rates of water use were reported to differ from those recorded on water taking permits, the figures quoted by the industry during the telephone survey were assumed to be correct (Table 3.1).

#### 3.2 FUTURE WATER DEMAND

Future water needs of industries not supplied by a municipal water system were estimated based on past trends.

A high correlation between population and permitted industrial water takings between the years 1963-1976 was found through regression analysis. By taking the natural logarithm of the population change and relating it to permitted industrial water takings for two year intervals, a semi-logarithmic curve fit was obtained, with a correlation co-efficient of

TABLE 3.1

Water Use By Industries Not Supplied by Municipal Water Supply Systems, 1980

| Sub-Basin Sector                | Type of Water Use |        |                      |        |          |       |         |        |                          |       |                    |       |               |       |       |        | % of Total<br>Water Use by<br>Sub-Basin Sector |      |
|---------------------------------|-------------------|--------|----------------------|--------|----------|-------|---------|--------|--------------------------|-------|--------------------|-------|---------------|-------|-------|--------|------------------------------------------------|------|
|                                 | Dewatering        |        | Aggregate<br>Washing |        | Sanitary |       | Cooling |        | Industrial<br>Processing |       | Food<br>Processing |       | Miscellaneous |       | Total |        |                                                |      |
|                                 | mgd               | mg/yr  | mgd                  | mg/yr  | mgd      | mg/yr | mgd     | mg/yr  | mgd                      | mg/yr | mgd                | mg/yr | mgd           | mg/yr | mgd   | mg/yr  |                                                |      |
| Lower Grand<br>River            | 5.74              | 1666.0 | 3.26                 | 728.0  | .01      | 3.3   | .22     | 55.1   | .11                      | 25.9  | .15                | 45.3  | .28           | 101.5 | 9.77  | 2625.1 | 30.2                                           | 31.2 |
| Whiteman Creek                  |                   |        |                      |        |          |       |         |        |                          |       |                    |       | .11           | 27.0  | .11   | 27.0   | .3                                             | .3   |
| Nith River                      |                   |        | 1.94                 | 471.1  | .20      | 58.7  | .08     | 26.2   |                          |       | 1.64               | 562.7 | .14           | 52.6  | 4.00  | 1171.3 | 12.3                                           | 13.9 |
| Paris                           |                   |        | 1.92                 | 468.5  |          |       |         |        |                          |       |                    |       |               |       | 1.92  | 468.5  | 5.9                                            | 5.6  |
| Middle Grand<br>River           |                   |        | 8.17                 | 1712.4 | .20      | 69.0  | 4.12    | 1337.4 | .46                      | 123.6 | .52                | 187.3 | .03           | 10.6  | 13.50 | 3440.3 | 41.8                                           | 40.9 |
| Conestogo                       |                   |        | 2.70                 | 567.0  | .02      | 6.1   | .04     | 15.8   | .23                      | 84.1  |                    |       | .08           | 16.0  | 3.07  | 689.0  | 9.5                                            | 8.1  |
| Upper Grand<br>River            |                   |        |                      |        |          |       |         |        |                          |       |                    |       |               |       |       |        |                                                |      |
| Total                           | 5.74              | 1666.0 | 17.99                | 3947.0 | .43      | 137.1 | 4.46    | 1434.5 | .80                      | 233.6 | 2.31               | 795.3 | .64           | 207.7 | 32.37 | 8421.2 | 100                                            | 100  |
| % of Total Water<br>Use By Type | 17.7              | 19.8   | 55.6                 | 46.8   | 1.3      | 1.6   | 13.8    | 17.0   | 2.5                      | 2.8   | 7.1                | 9.4   | 2.0           | 2.6   | 100   | 100    |                                                |      |
| % Ground Water                  | 100               | 100    | 34.7                 | 36.2   | 97.7     | 99.9  | 96.4    | 99.3   | 86.5                     | 88.9  | 100                | 100   | 100           | 100   | 62.9  | 69.3   |                                                |      |
| % Surface Water                 | --                | --     | 65.3                 | 63.8   | 2.3      | 0.1   | 3.6     | 0.7    | 13.5                     | 11.1  | --                 | --    | --            | --    | 37.1  | 30.7   |                                                |      |

0.78. Assuming that this relationship continues to the year 2031, a range in the amount of water needed in the future was predicted based on low, medium and high population projections.

Estimations of industrial water demand for each sub-basin sector were determined by assuming that the type and distribution of future industries would remain the same as existed in 1978 with the exception of the Middle Grand River sector.

Since almost half of the water extracted for industrial use in 1978 was taken from surface and ground-water sources within the Middle Grand River sector, future industrial water needs were estimated at a more detailed level for the major municipalities in this area.

In 1978, industries within Kitchener extracted 22.7% of the total daily water takings calculated for the Middle Grand River sector while 12.6%, 15.4%, and 49.3% of the total daily water takings were extracted by industries within Waterloo, Cambridge and Guelph respectively.

To estimate a realistic range for water demand, two assumptions were used: (1) the type and distribution of future industries and the industrial water sources for these industries will remain the same as existed in 1978, and (2) those industries extracting ground water within the municipal boundaries of the Cities of Kitchener, Waterloo and Cambridge will not be allowed in the future to extract more water than is currently permitted and newly established industries will be linked to the municipal water supply system. The remaining industries which extract surface water will continue to expand as predicted by the regression analysis. The second assumption is considered to be the most realistic for cities within the Regional Municipality of Waterloo since water managers are already closely scrutinizing water use and advocating that new industries be linked to a municipal supply system. Tables 3.2 and 3.3 outline the daily and yearly ranges in ground and surface water demand based on the above assumptions for the Cities of Kitchener, Waterloo, Cambridge and Guelph for the years 2001 and 2031. The estimated range in industrial water demand for each sub-basin sector is illustrated in Table 3.4.

TABLE 3.2

Estimated Daily Industrial Water Demand From Private Sources for Kitchener, Waterloo,  
Cambridge and Guelph, 2001 and 2031

| Municipality | Existing Water Demand (mgd) |              |        | Estimated Surface Water Demand (mgd) | Estimated Ground Water Demand (mgd) | Total Water Demand (mgd) | Estimated Surface Water Demand (mgd) | Estimated Ground Water Demand (mgd) | Total Water Demand (mgd) |
|--------------|-----------------------------|--------------|--------|--------------------------------------|-------------------------------------|--------------------------|--------------------------------------|-------------------------------------|--------------------------|
|              | Surface Water               | Ground Water | Total  | 2001                                 | 2001                                | 2001                     | 2031                                 | 2031                                | 2031                     |
| Kitchener    | 0.60                        | 2.466        | 3.066  | 1.1 - 1.3                            | 2.5 - 5.2                           | 3.6 - 6.5                | 1.6 - 2.1                            | 2.5 - 8.4                           | 4.1 - 10.5               |
| Waterloo     | --                          | 1.690        | 1.690  | -- --                                | 1.8 - 3.6                           | 1.8 - 3.6                | -- --                                | 1.8 - 5.8                           | 1.8 - 5.8                |
| Cambridge    | --                          | 2.089        | 2.089  | -- --                                | 2.1 - 4.4                           | 2.1 - 4.4                | -- --                                | 2.1 - 7.2                           | 2.1 - 7.2                |
| Guelph       | 2.208                       | 4.46         | 6.668  | 4.3 - 4.7                            | 8.6 - 9.4                           | 12.9 - 14.1              | 5.9 - 7.6                            | 11.9 - 15.3                         | 17.8 - 22.9              |
| Total        | 2.808                       | 10.705       | 13.513 | 5.4 - 6.0                            | 15.0 - 22.6                         | 20.4 - 28.6              | 7.5 - 9.7                            | 18.3 - 36.7                         | 25.8 - 46.4              |

3.4

TABLE 3.3

Estimated Yearly Industrial Water Demand From Private Sources for Kitchener, Waterloo, Cambridge and Guelph

| Municipality | Existing Water Demand (mg/yr) |              |          | Estimated Surface Water Demand (mg/yr) | Estimated Ground Water Demand (mg/yr) | Total Water Demand (mg/yr) | Estimated Surface Water Demand (mg/yr) | Estimated Ground Water Demand (mg/yr) | Total Water Demand (mg/yr) |
|--------------|-------------------------------|--------------|----------|----------------------------------------|---------------------------------------|----------------------------|----------------------------------------|---------------------------------------|----------------------------|
|              | Surface Water                 | Ground Water | Total    | 2001                                   | 2001                                  | 2001                       | 2031                                   | 2031                                  | 2031                       |
| Kitchener    | 111.00                        | 793.40       | 904.40   | 213.3 - 234.6                          | 793.4 - 1,677.0                       | 1,006.7 - 1,911.6          | 297.0 - 380.6                          | 793.4 - 2,720.7                       | 1,090.4 - 3,101.3          |
| Waterloo     | --                            | 564.62       | 564.62   | -- --                                  | 582.3 - 1,202.2                       | 582.3 - 1,202.2            | -- --                                  | 593.5 - 1,950.4                       | 593.5 - 1,950.4            |
| Cambridge    | --                            | 397.39       | 397.39   | -- --                                  | 397.4 - 840.0                         | 397.4 - 840.0              | -- --                                  | 397.4 - 1,362.8                       | 397.4 - 1,362.8            |
| Guelph       | 437.52                        | 1,136.58     | 1574.10  | 840.7 - 924.8                          | 2,183.9 - 2,402.3                     | 3,024.6 - 3,327.1          | 1,170.6 - 1,500.3                      | 3,040.6 - 3,897.6                     | 4,211.2 - 5,397.9          |
| Total        | 548.52                        | 2,891.99     | 3,440.51 | 1,054.0 - 1,159.4                      | 3,957.0 - 6,121.5                     | 5,011.0 - 7,280.9          | 1,467.6 - 1,880.9                      | 4,824.9 - 9,931.5                     | 6,292.5 - 11,812.4         |

TABLE 3.4

Future Water Demand Estimates for Industries Not Supplied by  
Municipal Water Supply Systems

| Sub-Basin Sector                | Existing Water<br>Demand<br>mgd (mg/yr) | % Groundwater<br>Source<br>mgd (mg/yr) | Estimated Range for<br>Water Demand<br>2001<br>mgd (mg/yr) | Estimated Range for<br>Water Demand<br>2031<br>mgd (mg/yr) |
|---------------------------------|-----------------------------------------|----------------------------------------|------------------------------------------------------------|------------------------------------------------------------|
| Lower Grand<br>River            | 9.8 (2,625)                             | 82 (89)                                | 19.0 - 20.8 (5,139 - 5,626)                                | 26.5 - 33.9 (7,167 - 9,169)                                |
| Whiteman Creek                  | 0.1 (27)                                | 100 (100)                              | 0.2 - 0.2 (54 - 54)                                        | 0.3 - 0.3 (81 - 81)                                        |
| Nith River                      | 4.0 (1,171)                             | 52 (60)                                | 7.5 - 8.2 (2,151 - 2,352)                                  | 10.4 - 13.4 (2,983 - 3,844)                                |
| Paris and Middle<br>Grand River | 15.4 (3,909)                            | 46 (54)                                | 24.0 - 32.7 (5,889 - 8,281)                                | 30.9 - 53.0 (7,537 - 13,422)                               |
| Conestogo River                 | 3.1 (689)                               | 100 (100)                              | 6.0 - 6.6 (1,333 - 1,467)                                  | 8.3 - 10.6 (1,845 - 2,356)                                 |
| Upper Grand<br>River            | 0                                       | -- --                                  | -- -- -- --                                                | -- -- -- --                                                |
| Total                           | 32.4 (8,421)                            | 63 (69)                                | 56.7 - 68.5 (14,566 - 17,780)                              | 76.4 - 111.2 (19,613 - 28,872)                             |

### 3.3 IMPLICATIONS OF INDUSTRIAL WATER DEMAND PROJECTION

The projections for industrial water consumption for those industries with private water supplies indicate that the critical areas where existing water supply may become insufficient to meet demand are in the central basin, specifically in the Cities of Kitchener, Waterloo, Cambridge and Guelph. For these four municipalities, an increase in ground-water demand from 40% to 111% is projected by the year 2001. Concurrently, surface water demand is expected to more than double in Kitchener and Guelph.

If the low estimate for industrial water demand is realized, adequate water supplies will be available in the central basin to meet industrial needs. Since the low estimate represents a situation where no new demand for ground-water supplies will occur in the Cities of Kitchener, Waterloo and Cambridge, a further increase in abstraction of ground water for industrial purposes would affect the availability of water for municipal use requiring the implementation of water supply projects before they would otherwise be needed.

#### 4. AGRICULTURAL WATER DEMAND

##### 4.1 IRRIGATION

###### 4.1.1 Existing Water Use

Water withdrawal for irrigation of field crops such as tobacco, vegetables and other market garden crops is authorized by permit by the Ontario Ministry of the Environment and represents a significant portion of total permitted water takings within the Grand River basin (Appendix E)\*. Demand for irrigation occurs primarily in the tobacco growing areas. In 1978, approximately 85% of all authorized water takings were issued in the watersheds of Whiteman Creek, Mt. Pleasant Creek and McKenzie Creek. Total demand in these areas was estimated by means of a telephone survey at 230, 103, and 73 million gallons per season\*\* (1 045 000, 468 190 and 331 830 m<sup>3</sup>/season) respectively (Frigon, 1979). To estimate the number of days of irrigation during the season for these watersheds, it was assumed that the maximum daily withdrawal of water approximates the daily rate of withdrawal authorized by permit. In order to meet total demand per season, it was calculated that, on the average, a total of 5 days of continuous irrigation was necessary, distributed over two or three applications.

To determine total water demand per season within the entire basin during 1978, it was assumed that irrigation practices were similar in other sub-basins where irrigation was authorized by permit. By multiplying total water takings (mgd) allowed for each sub-basin by the average number of days per season required for irrigation as calculated above, total water demand was estimated (Table 4.1).

###### 4.1.2 Future Water Demand

To predict future water needs for irrigation throughout the Grand River basin, two basic assumptions were made:

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\* Appendix E has been updated to September 1982. Calculations for water demand for irrigation purposes are based on permitted water takings to December 1978.

\*\* A season refers to the 92 day period between June and August.



TABLE 4.1

Existing and Estimated Irrigation Needs for Row Crops\*, 2001 - 2031

| Basin Sector                                     | Existing Water Demand<br>(mg)<br>(1978) | Scenario 1<br>Estimated Water Demand<br>(mg) |         | Scenario 2<br>Estimated Water Demand<br>(mg) |         | Scenario 3<br>Estimated Water Demand<br>(mg) |         | Scenario 4<br>Estimated Water Demand<br>(mg) |        |
|--------------------------------------------------|-----------------------------------------|----------------------------------------------|---------|----------------------------------------------|---------|----------------------------------------------|---------|----------------------------------------------|--------|
|                                                  |                                         | 2001                                         | 2031    | 2001                                         | 2031    | 2001                                         | 2031    | 2001                                         | 2031   |
| Upper Grand River                                | --                                      | 50.72                                        | 84.54   | 50.72                                        | 75.56   | 50.72                                        | 84.54   | 22.83                                        | 22.83  |
| Conestogo River                                  | --                                      | 58.89                                        | 82.71   | 36.41                                        | 52.34   | 58.89                                        | 82.71   | 30.48                                        | 30.48  |
| Middle Grand River                               |                                         | 577.26                                       | 602.77  | 483.31                                       | 484.25  | 515.16                                       | 575.71  | 224.50                                       | 224.50 |
| Paris                                            | 11.12                                   | 13.97                                        | 13.97   | 12.15                                        | 12.15   | 13.97                                        | 13.97   | 11.21                                        | 11.21  |
| Nith River                                       | 44.97                                   | 539.65                                       | 613.63  | 470.86                                       | 539.78  | 451.83                                       | 547.14  | 311.09                                       | 311.09 |
| Whiteman Creek                                   | 268.70                                  | 384.29                                       | 384.29  | 326.31                                       | 326.31  | 384.22                                       | 384.29  | 237.68                                       | 237.68 |
| Lower Grand River                                | 161.73                                  | 212.27                                       | 222.28  | 199.91                                       | 207.00  | 187.98                                       | 208.75  | 94.15                                        | 94.15  |
| Total Water Demand                               | 486.62                                  | 1837.05                                      | 2004.19 | 1579.67                                      | 1697.39 | 1662.77                                      | 1897.11 | 931.94                                       | 931.94 |
| Additional Water Demand<br>Above 1978 level (MG) |                                         | 1350.43                                      | 1517.56 | 1093.04                                      | 1210.76 | 1176.14                                      | 1410.48 | 445.31                                       | 445.31 |

\*Calculated for a 92 day period from June to August.

1. Any irrigation that would take place within the basin would be on sandy and sandy loam soils in which row crops are grown (Ayers, 1980).
2. Water would be applied to an area of corn at a rate of 1 inch per application and an area of other row crops at a rate of .85 inches per application, assuming three applications per season (June-August) (Brown, 1980).

To determine the area of row crops which might be grown on sandy and sandy loam soils in the future the following methodology was used:

1. The percentage of each sub-basin within the watershed exhibiting sandy and sandy loam soils was estimated with the aid of soil survey documents.
2. It was assumed that the distribution of row crops and sandy and sandy loam soils would be homogeneous throughout a particular sub-basin.
3. The area of sandy and sandy loam soils in row crops was calculated by assuming that the proportion of sandy and sandy loam soils within a particular sub-basin would be similar to the proportion of sandy and sandy loam soils within an area planted in row crops. For example, if 10% of a particular sub-basin consisted of sandy and sandy loam soils, 10% of the area of row crops would be planted in sandy and sandy loam soils.
4. The future area of row crops was given as estimated in Technical Report No. 8 "Existing and Future Land Use Activities Within the Grand River Basin" (Veale, 1980 a).

Although it is acknowledged that the above assumptions may not be realistic, it is felt that the given methodology provides a "ball park" estimate of the area of row crops in sandy and sandy loam soils within a particular sub-basin. Information and time constraints precluded a more in-depth analysis.

Technical Report No. 8 outlines four scenarios which provide a range for the future area and distribution of row crops. The amount of irrigation needed for each sub-basin varies according to the particular scenario used.

To predict water needs for each sub-basin, the area of row crops in sandy and sandy loam soils was calculated for each scenario and the amount of irrigation required was determined by assuming three applications of water of 1 inch (25.4 mm) over the projected area of corn and .85 inch (21.59 mm) over the projected area of other row crops.

Results are given in millions of gallons per season for the sub-basins delineated in Figure 1.1. Total additional water demand after 1978 was calculated by subtracting the 1978 demand from the projected total water demand (Table 4.1; Appendix F; and Tables F1.1 to F1.4).

#### 4.1.3 Implications of Irrigation Water Demand Projections

Since over 88% of the water extracted for crop irrigation is from surface sources, the following methodology was used to estimate whether or not there is enough available surface water to meet projected irrigation needs.

Statistics detailing the mean flow experienced during the months of June, July and August were collected from surface water records for seven gauging stations: Grand River near Marsville (GA14); Conestogo River at Drayton (GA17); Canagagigue Creek near Elmira (GA23); Speed River above Guelph (GA20); Eramosa River above Guelph (GA29); Nith river near Canning (GA10); and Whiteman Creek near Mount Vernon(GB8). At least 12 consecutive years of flow data were used to calculate the probability of non-exceedance for summer run-off at each gauging station with the exception of the gauge above Guelph on the Speed River where only 8 years of data were available. These data were plotted on log probability paper and run-off equivalents to 50, 10 and 5 percent probability of non-exceedance were estimated. Table 4.2 indicates the inches of run-off estimated for the 50, 10 and 5 percent probability of non-exceedance levels for the seven gauging stations.

To determine the run-off equivalents at the selected probability levels for each sub-basin, two factors were taken into consideration; the run-off equivalents calculated at the nearest downstream gauging station and the drainage characteristics relative to each sub-basin. Those sub-basins with corresponding drainage characteristics adjacent to a sub-basin for which run-off equivalents were estimated, were assigned the same run-off equivalents. However, in the case of the sub-basin below Guelph on the Speed River, the most relevant run-off equivalents were considered to be those estimated for Whiteman Creek since drainage characteristics of the two areas are similar, (Figure 4.1; and Table 4.2).

Supply of surface water for each sub-basin in millions of gallons for the summer months (June-August) was calculated by multiplying the run-off equivalents for the probability levels chosen, by the sub-basin drainage area.

Assuming that the majority of irrigable crops are distributed in the middle and lower areas of the sub-basins, results indicate that there is more than enough surface water available for irrigation spread over the three month period. Table 4.3 shows that with a 95% probability of run-off being exceeded (or a .05% probability of run-off not being exceeded), there is an adequate supply of surface water for each sub-basin sector. However, some water storage may be required if water were needed for irrigation in more than one application during a specific month under maximum water demand conditions in two sub-basins; the Conestogo River below the Conestogo Dam, and the Speed River above Guelph.

## 4.2 LIVESTOCK

### 4.2.1 Existing Water Use for Livestock

In addition to water uses related to irrigation, water is also consumed in significant quantities by livestock. The water consumed by livestock is not included under water permits for irrigation but is extracted from private domestic wells or surface sources such as streams and/or farm ponds. The water used by livestock was estimated for the year 1976 by

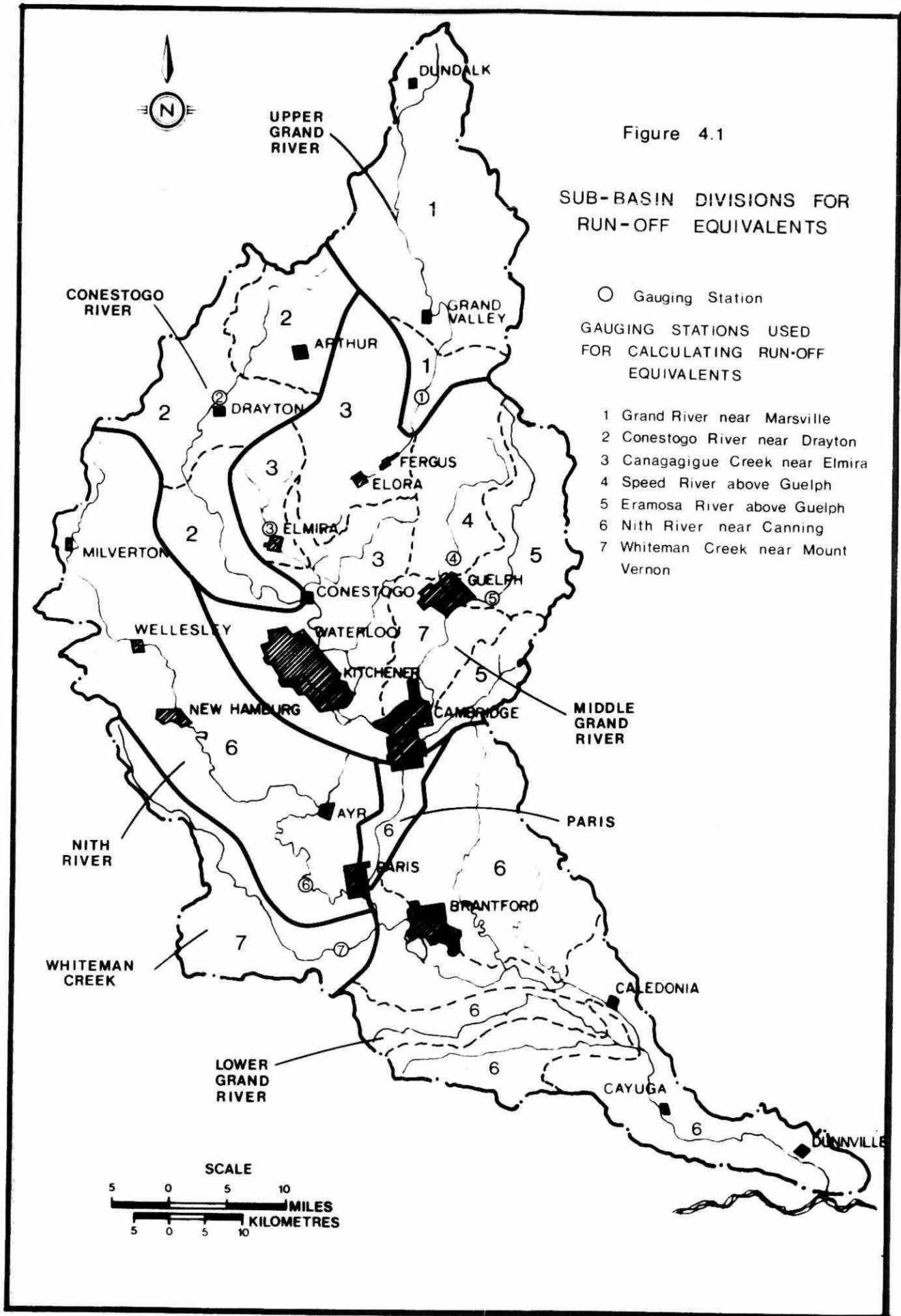


TABLE 4.2  
Estimated Inches of Run-Off at 50, 10 and 5 Percent  
Probability of Non-Exceedance

| Gauging Station                           | Drainage Area  | Inches of Run-Off<br>% Probability of Non-Exceedance (June-August) |     |      |
|-------------------------------------------|----------------|--------------------------------------------------------------------|-----|------|
|                                           |                | .50                                                                | .10 | .05  |
| GA14 - Grand River<br>near Marsville      | 268 Sq. Miles  | .80                                                                | .40 | .28  |
| GA17 - Conestogo River<br>at Drayton      | 125 Sq. Miles  | .40                                                                | .07 | .065 |
| GA23 - Canagagigue<br>Creek near Elmira   | 45.4 Sq. Miles | 1.09                                                               | .33 | .28  |
| GA20 - Speed River<br>above Guelph        | 104 Sq. Miles  | 1.33                                                               | .28 | .24  |
| GA29 - Eramosa River<br>above Guelph      | 91 Sq. Miles   | 1.43                                                               | .99 | .97  |
| GA10 - Nith River<br>near Canning         | 398 Sq. Miles  | 1.20                                                               | .75 | .65  |
| GB8 - Whiteman Creek<br>near Mount Vernon | 148 Sq. Miles  | 1.00                                                               | .70 | .65  |

TABLE 4.3

## Estimated Agricultural Irrigation Water Demand and Surface Water Supply

| Sector                                  | Associated Sub-Basins                                                                   | Total Area<br>of Sector<br>(ha) | Estimated Maximum Water<br>Demand (mg) |        | Estimated Supply (mg)<br>Probability of Flow Being Exceeded |       |       |  |
|-----------------------------------------|-----------------------------------------------------------------------------------------|---------------------------------|----------------------------------------|--------|-------------------------------------------------------------|-------|-------|--|
|                                         |                                                                                         |                                 | 2001                                   | 2031   | .50                                                         | .90   | .95   |  |
| <u>Upper Grand River</u>                |                                                                                         |                                 |                                        |        |                                                             |       |       |  |
| a) Grand River above Lake Belwood       | GA0101; GA0102                                                                          | 68 898                          | 19.80                                  | 34.72  | 3,064                                                       | 1,532 | 1,073 |  |
| b) Grand River above Shand Dam          | GA0103                                                                                  | 13 400                          | 30.92                                  | 49.82  | 596                                                         | 298   | 208   |  |
| Total                                   |                                                                                         | 82 298                          | 50.72                                  | 84.54  | 3,660                                                       | 1,830 | 1,281 |  |
| <u>Conestogo River</u>                  |                                                                                         |                                 |                                        |        |                                                             |       |       |  |
| a) Conestogo River above Conestogo Lake | GA0601                                                                                  | 27 707                          | 7.02                                   | 12.22  | 616                                                         | 108   | 100   |  |
| b) Conestogo River above Conestogo Dam  | GA0602                                                                                  | 28 829                          | 14.45                                  | 25.18  | 633                                                         | 112   | 104   |  |
| c) Conestogo River below Conestogo Dam  | GA0603; GA0604                                                                          | 26 562                          | 37.42                                  | 45.31  | 488                                                         | 103   | 96    |  |
| Total                                   |                                                                                         | 83 098                          | 58.89                                  | 82.71  | 1,737                                                       | 323   | 300   |  |
| <u>Middle Grand River</u>               |                                                                                         |                                 |                                        |        |                                                             |       |       |  |
| a) Grand River above West Montrose      | GA0104                                                                                  | 36 752                          | 124.34                                 | 143.51 | 2,227                                                       | 674   | 572   |  |
| b) Canagagigue Creek                    | GA0105; GA0106                                                                          | 10 761                          | 30.44                                  | 30.44  | 651                                                         | 197   | 168   |  |
| c) Speed River above Guelph             | GA0401; GA0402                                                                          | 27 853                          | 341.54                                 | 341.54 | 2,060                                                       | 434   | 372   |  |
| d) Speed River below Guelph             | GA0403; GA0404; GA0405;<br>GA0406; GA0407; GA0408                                       | 22 977                          | 54.14                                  | 54.14  | 1,276                                                       | 893   | 830   |  |
| e) Eramosa River above Guelph           | GA05                                                                                    | 26 505                          | 25.25                                  | 32.27  | 2,107                                                       | 1,459 | 1,429 |  |
| f) Galt Creek                           | GA0301; GA0302; GA0303; GA0304                                                          | 9 926                           | 1.55                                   | 1.55   | 789                                                         | 541   | 535   |  |
| g) Grand River above Cambridge          | GA0107; GA0108; GA0109;<br>GA0110                                                       | 50 973                          | --                                     | --     | 3,091                                                       | 936   | 794   |  |
| Total                                   |                                                                                         | 185 747                         | 577.26                                 | 603.45 | 12,201                                                      | 5,134 | 4,700 |  |
| <u>Paris</u>                            |                                                                                         |                                 |                                        |        |                                                             |       |       |  |
|                                         | GA0111                                                                                  | 9 617                           | 13.97                                  | 13.97  | 641                                                         | 401   | 348   |  |
| <u>Nith River</u>                       |                                                                                         |                                 |                                        |        |                                                             |       |       |  |
|                                         | GA0201; GA0202; GA0203;<br>GA0204; GA0205; GA0206;<br>GA0207; GA0208; GA0209;<br>GA0210 | 114 617                         | 539.65                                 | 613.63 | 7,648                                                       | 4,780 | 4,142 |  |
| <u>Whiteman Creek</u>                   |                                                                                         |                                 |                                        |        |                                                             |       |       |  |
|                                         | GB0501; GB0502                                                                          | 40 754                          | 384.29                                 | 384.29 | 2,265                                                       | 1,586 | 1,473 |  |
| <u>Lower Grand River</u>                |                                                                                         |                                 |                                        |        |                                                             |       |       |  |
| a) Fairchild and Big Creek              | GB04; GB03                                                                              | 58 878                          | 22.13                                  | 22.13  | 3,843                                                       | 2,402 | 2,128 |  |
| b) McKenzie Creek                       | GB0201                                                                                  | 20 297                          | 60.50                                  | 60.60  | 1,354                                                       | 846   | 734   |  |
| c) Boston Creek                         | GB0202                                                                                  | 23 083                          | 28.04                                  | 36.08  | 1,540                                                       | 963   | 834   |  |
| d) Grand River below Brantford          | GB0101; GB0102; GB0103                                                                  | 78 877                          | 101.60                                 | 112.73 | 5,262                                                       | 3,289 | 2,050 |  |
| Total                                   |                                                                                         | 181 135                         | 212.27                                 | 234.54 | 11,999                                                      | 7,500 | 6,546 |  |
| Total Watershed                         |                                                                                         | 696 466                         |                                        |        |                                                             |       |       |  |

assuming that milk and other cows consume an average of 40 and 15 gallons (181.84 and 68.19 L) of water per day respectively while sheep and pigs consume 2 gallons (9.09 L) per day (Frigon, 1979) (Appendix G; and Table G1.1).

#### 4.2.2 Future Water Demand by Livestock

Two projections of the future number of animal units within the watershed to the year 2031 are given in Technical Report No. 8 (Veale, 1980 a). One scenario assumes that the change in animal units within each sub-basin sector will follow past trends. The second scenario assumes that the number and distribution of animal units will remain relatively unaltered in the future. Since the second scenario predicts a "no change" situation, minimum future water demand is expected to remain at the 1976 level. To predict the number of cattle, sheep and pigs which may be raised within the basin, according to the first scenario it was assumed that the 1976 proportion of animal units from each livestock type would remain stable to the year 2001. These projections are outlined in Appendix G, Table G1.1, G1.2 and G1.3.

Assuming that the average daily consumption rates remain the same for each livestock type, an estimate of future water demand for livestock was derived as given in Table 4.4 by sub-basin sector.

#### 4.2.3 Implications of Livestock Water Demand

The projected increase in the amount of water needed for livestock consumption is approximately 1.432 million gallons (6 509.24 m<sup>3</sup>) by the year 2001 and 3.223 million gallons (14 650.33 m<sup>3</sup>) by the year 2031. Significant increases may occur in three sub-basins - the Nith, Middle Grand and Conestogo - however, water shortages are not anticipated.



TABLE 4.4

Livestock Water Demand in the Grand River Basin, 1976, 2001 and 2031

| <u>Sub-Basin Sector</u> | <u>Estimated<br/>Livestock Water<br/>Demand, 1976<br/>(gpd)</u> | <u>Estimated<br/>Livestock Water<br/>Demand, 2001<br/>(gpd)</u> | <u>Estimated<br/>Livestock Water<br/>Demand, 2031<br/>(gpd)</u> |
|-------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|
| Lower Grand River       | 1,265,098                                                       | 365,910                                                         | 365,910                                                         |
| Whiteman Creek          | 443,801                                                         | 452,160                                                         | 352,904                                                         |
| Nith River              | 1,891,482                                                       | 2,650,324                                                       | 3,076,728                                                       |
| Paris                   | 98,337                                                          | 99,194                                                          | 89,413                                                          |
| Middle Grand River      | 1,545,861                                                       | 2,828,085                                                       | 3,717,265                                                       |
| Conestogo River         | 1,762,739                                                       | 1,981,580                                                       | 2,566,692                                                       |
| Upper Grand River       | <u>690,712</u>                                                  | <u>753,006</u>                                                  | <u>753,006</u>                                                  |
| Total                   | 7,698,030                                                       | 9,130,259                                                       | 10,921,918                                                      |

## 5. OTHER WATER DEMAND

Existing and future water demand for the primary water users within the basin has been outlined in previous chapters. Further demand is placed on water resources for rural domestic, commercial and recreational activities. The nature and extent of this demand and its implications for future water management are outlined in the following sections.

### 5.1 RURAL DOMESTIC

While the majority of the basin population is serviced by municipal water supply systems, the remaining 19% obtains water from private sources, primarily wells. In the Lower Grand River sector, a limited number of residents supplement well water (used mostly for drinking) with rain water collected in cisterns (used mainly for washing).

The daily water demand by the unserviced rural population in the basin was estimated by the Ontario Ministry of the Environment in 1978, based on water taking permit records. The average per capita consumption rate ranged between 49 and 51 gallons per day (222.73 L/day, 231.82 L/day). Total water use for rural domestic purposes was estimated at 5.583 mgd ( $25.37 \text{ m}^3 \times 10^3$ ) or 2,038 mg/yr (9 262.94). Rural domestic water use by sub-basin sector is outlined in Table 5.1.

Future domestic water demand was estimated using the assumption that average per capita consumption rates will remain stable between the years 1978 and 2031. A range in future demand by sub-basin sector was obtained by multiplying the projected populations outlined in Table 2.6 by an average per capita consumption rate of 50 gallons per day (227.28 L/day) (Table 5.1).

The projected increase in rural domestic water demand is between 0.621 and 2.499 mgd (2 822.8 and 11 359.3  $\text{m}^3/\text{d}$ ) by the year 2001 and 1.476 and 7.888 mgd (6 709.2 and 35 855.4  $\text{m}^3/\text{d}$ ) by the year 2031. Increases in demand are expected in all sub-basins. No water shortages are anticipated to the year 2031.

TABLE 5.1

## Rural Domestic Water Demand Estimates

| Sub-Basin Sector   | Estimated Water Demand (mgd), 1978 | Estimated Water Demand (mgd), 2001 |              |              |              | Estimated Water Demand (mgd), 2031 |              |              |              |
|--------------------|------------------------------------|------------------------------------|--------------|--------------|--------------|------------------------------------|--------------|--------------|--------------|
|                    |                                    | Low Low Proj.                      | Low Proj.    | Med. Proj.   | High Proj.   | Low Low Proj.                      | Low Proj.    | Med. Proj.   | High Proj.   |
| Upper Grand River  | .322                               | .333                               | .333         | .496         | .635         | .432                               | .432         | .873         | 1.371        |
| Conestogo River    | .696                               | .766                               | .790         | .915         | 1.052        | .933                               | .941         | 1.399        | 1.958        |
| Middle Grand River | 1.649                              | 1.728                              | 1.790        | 2.053        | 2.357        | 2.091                              | 2.110        | 3.091        | 4.320        |
| Paris              | .115                               | .120                               | .127         | .138         | .149         | .134                               | .136         | .183         | .221         |
| Nith River         | 1.035                              | 1.095                              | 1.158        | 1.267        | 1.374        | 1.274                              | 1.293        | 1.746        | 2.137        |
| Whiteman Creek     | .348                               | .388                               | .388         | .436         | .493         | .431                               | .431         | .558         | .731         |
| Lower Grand River  | <u>1.418</u>                       | <u>1.774</u>                       | <u>1.774</u> | <u>1.848</u> | <u>2.022</u> | <u>1.764</u>                       | <u>1.764</u> | <u>2.122</u> | <u>2.733</u> |
| Total mgd          | 5.583                              | 6.204                              | 6.360        | 7.153        | 8.082        | 7.059                              | 7.107        | 9.972        | 13.471       |
| Total mg/yr        | 2037.80                            | 2264.46                            | 2321.40      | 2610.85      | 2949.93      | 2576.54                            | 2594.06      | 3639.78      | 4916.92      |

## 5.2 COMMERCIAL

While most commercial establishments are connected to a municipal service system, some have been granted permits for obtaining water from private sources by the Ontario Ministry of the Environment. Over 90% of these permits allow ground-water extraction, primarily for the purpose of maintaining viable fish farm enterprises. Table 5.2 indicates the daily and yearly water takings for commercial purposes within the basin. The yearly volume of water was calculated by assuming that commercial establishments consume the maximum amount of water which is allowed daily for use by permit for the number of days allocated for the duration of a year. An inventory of daily commercial water takings by establishment is provided in Appendix D, Tables D1.1 to D1.6.

The use of water by commercial establishments in the future is not expected to increase significantly.

## 5.3 RECREATIONAL

Recreational uses of water are, for the most part, confined to natural surface water areas or storage ponds. A limited amount of water is extracted for irrigating golf courses, conducting agricultural research and supplying park areas.

The daily water takings for recreational use are approved by the Ontario Ministry of the Environment. The quantity of water allowed for recreational use in each sub-basin sector is shown in Table 5.2. and Appendix E. To estimate the yearly volume of water used for irrigating golf courses, a water use telephone survey was conducted during the fall, 1980. Based on the results of the study, it was estimated that, on the average, golf course operators extract the maximum amount of water allotted daily by the Ministry for approximately 80 days per year. To estimate the yearly volume of water used for other recreational purposes, it was assumed that water is withdrawn for 60 days per year. Table 5.2 outlines daily permitted water takings and the estimated yearly volumes of water withdrawn for recreational uses.

It is expected that water abstraction for recreational use will not increase significantly in the future.

TABLE 5.2

## Existing Water Demand for Commercial and Recreational Uses, 1978

| <u>Sub-Basin Sector</u>                    | <u>Commercial<br/>(gpd)</u> | <u>Recreational<br/>(gpd)</u>      | <u>Irrigation<br/>(Golf) (gpd)</u> |
|--------------------------------------------|-----------------------------|------------------------------------|------------------------------------|
| Lower Grand River                          | 333,000                     | 13 storage<br>ponds                | 391,680                            |
| Whiteman Creek                             |                             | 17 storage<br>ponds                |                                    |
| Nith River                                 |                             | 21,600 +<br>17 storage<br>ponds    | 121,800                            |
| Paris and Middle<br>Grand River            | 1,569,600                   | 2,353,200<br>+ 28 storage<br>ponds | 1,665,700                          |
| Conestogo River                            |                             | 3 storage<br>ponds                 |                                    |
| Upper Grand River                          |                             | 3 storage<br>ponds                 |                                    |
| Total Estimated<br>Withdrawal Rate         | 1,902,600                   | 2,374,800                          | 2,179,180                          |
| Total Estimated<br>Withdrawal<br>Volume/Yr | 653,679,000                 | 142,488,000                        | 174,334,400                        |

## 6. SUMMARY

The total known yearly water withdrawals in the Grand River basin approximate  $34 \times 10^3$  mg ( $155 \times 10^6$  m<sup>3</sup>) (Table 6.1 and Figure 6.1). Daily consumption ranges from an average of about 100 mgd ( $455\,500$  m<sup>3</sup>/d) to a maximum of 202 mgd ( $918\,000$  m<sup>3</sup>/d) during the summer months, assuming maximum withdrawal for irrigation and recreational uses (Table 6.1 and Figure 6.2).

The range in yearly water withdrawals in the Grand River watershed is expected to increase to between  $60 \times 10^3$  mg ( $273 \times 10^6$  m<sup>3</sup>) and  $80 \times 10^3$  mg ( $403 \times 10^6$  m<sup>3</sup>) in the year 2001 and  $78 \times 10^3$  mg ( $355 \times 10^6$  m<sup>3</sup>) and  $129 \times 10^3$  ( $586 \times 10^6$  m<sup>3</sup>) in the year 2031 (Tables 6.1 and 6.2; and Figure 6.1).

The range in daily water use is expected to increase from an average between 178 and 235 mgd ( $809\,100$  and  $1\,068\,200$  m<sup>3</sup>/d) to a maximum between 369 and 606 mgd ( $1\,677\,300$  and  $2\,754\,600$  m<sup>3</sup>/d) in the year 2001. By the year 2031, this daily range is further increased from an average between 233 and 379 mgd ( $1\,059\,218$  m<sup>3</sup>/d and  $1\,772\,934$  m<sup>3</sup>/d) to a maximum between 424 and 785 mgd ( $1\,927\,504$  m<sup>3</sup>/d and  $3\,568\,610$  m<sup>3</sup>/d) (Tables 6.2 and 6.3; and Figure 6.2).

The critical areas where water shortages may occur in the future are in the central basin. In the Cities of Kitchener, Waterloo, Cambridge and Guelph, the existing water supply must be supplemented by new water sources by the year 2001 if no conservation measures or new pricing structures are implemented. Two smaller communities, Fergus and Elora, may experience water shortages by the year 2031. The time at which new municipal supplies are required is dependent on population growth and water conservation practices.

TABLE 6.1

Estimates of Existing Water Demand in the Grand River Basin, 1976 - 1979

| Sub-Basin Sector                             | Domestic<br>Rural (gpd)<br>1979 | Livestock<br>(gpd)<br>1976 | Irrigation<br>Crops/Sod<br>(gpd)<br>1979 | Irrigation<br>Golf<br>(gpd)<br>1979 | Municipal<br>(gpd)<br>1979 | Industrial<br>(gpd)<br>1978-79 | Commercial<br>(gpd)<br>1979 | Recreational<br>(gpd)<br>1979      | Total<br>(gpd) |
|----------------------------------------------|---------------------------------|----------------------------|------------------------------------------|-------------------------------------|----------------------------|--------------------------------|-----------------------------|------------------------------------|----------------|
| Lower Grand River                            | 1,419,000                       | 1,265,099                  | 32,345,215<br>+ 1 storage<br>pond        | 391,680                             | 1,542,000                  | 9,764,000                      | 333,000                     | 13 storage<br>ponds                | 47,059,993     |
| Whiteman Creek                               | 349,000                         | 443,901                    | 53,740,572                               |                                     |                            | 109,000                        |                             | 1 storage<br>pond                  | 54,640,373     |
| Nith River                                   | 1,035,000                       | 1,991,492                  | 9,993,550                                | 121,900                             | 14,790,000                 | 3,996,000                      |                             | 21,600<br>+ 17 storage<br>ponds    | 30,939,432     |
| Paris and<br>Middle Grand<br>River           | 1,764,000                       | 1,644,199                  | 2,245,960                                | 1,665,700                           | 36,069,000                 | 15,446,000                     | 1,612,900                   | 2,353,200<br>+ 29 storage<br>ponds | 62,900,759     |
| Conestogo River                              | 696,000                         | 1,762,739                  |                                          |                                     | 420,000                    | 3,069,000                      |                             | 3 storage<br>ponds                 | 5,946,739      |
| Upper Grand River                            | 322,000                         | 690,712                    |                                          |                                     | 35,000                     |                                |                             | 3 storage<br>ponds                 | 1,047,712      |
| Total Estimated<br>Withdrawal Rate           | 5,593,000<br>2.9%               | 7,699,030<br>3.9%          | 97,325,197<br>49.1%                      | 2,179,180<br>1.1%                   | 52,946,000<br>26.1%        | 32,392,000<br>16.0%            | 1,945,900<br>0.9%           | 2,374,900<br>1.2%                  | 202,334,007    |
| Total Estimated<br>Withdrawal<br>Volumes/yr. | 2,037,795,000<br>6.0%           | 2,809,790,950<br>9.3%      | 486,625,995<br>1.4%                      | 174,334,400<br>0.5%                 | 19,299,790,000<br>56.7%    | 9,425,179,000<br>24.9%         | 69,374,000<br>1.9%          | 142,499,000<br>0.4%                | 34,034,366,335 |

TABLE 6.2

Estimates of Future Water Demand in the Grand River Basin, 2001

| Sub-Basin Sector                             | Livestock<br>(mgd) | Irrigation<br>Crops/Sod<br>(mgd) | Irrigation<br>Golf<br>(mgd) | Recreational<br>(mgd) | Municipal<br>(mgd)  | Industrial<br>(mgd) | Commercial<br>(mgd) | Domestic<br>Rural<br>(mgd) | Total Water<br>Demand<br>(mgd) |
|----------------------------------------------|--------------------|----------------------------------|-----------------------------|-----------------------|---------------------|---------------------|---------------------|----------------------------|--------------------------------|
| Lower Grand River                            | 0.37 - 1.27        | 18.83 - 42.45                    | 0.39 - 0.39                 |                       | 22.4 - 31.4         | 19.0 - 20.8         | 0.33 - 0.33         | 1.774 - 2.022              | 63.094 - 98.502                |
| Whiteman Creek                               | 0.44 - 0.45        | 47.54 - 76.86                    | -                           |                       | -                   | 0.2 - 0.2           | -                   | 0.388 - 0.493              | 48.568 - 78.003                |
| Nith River                                   | 1.89 - 2.65        | 62.22 - 107.93                   | 0.12 - 0.12                 | .02 - .02             | 3.28 - 3.88         | 7.5 - 8.2           | -                   | 1.095 - 1.374              | 76.125 - 124.174               |
| Paris and Middle<br>Grand River              | 1.64 - 2.93        | 47.14 - 118.25                   | 1.66 - 1.66                 | 2.35 - 2.35           | 79.78 - 109.45      | 24.0 - 32.7         | 1.61 - 1.61         | 1.848 - 2.506              | 160.028 - 271.456              |
| Conestogo River                              | 1.76 - 1.98        | 6.10 - 11.78                     |                             |                       | 0.55 - 0.69         | 6.0 - 6.6           |                     | 0.766 - 1.052              | 15.176 - 22.102                |
| Upper Grand River                            | 0.69 - 0.75        | 4.57 - 10.14                     |                             |                       | 0.51 - 0.70         | -                   |                     | 0.333 - 0.635              | 6.103 - 12.225                 |
| Total Estimated<br>Withdrawal Rate           | 6.79 - 10.03       | 186.40 - 367.41                  | 2.17 - 2.17                 | 2.37 - 2.37           | 106.52 - 145.96     | 56.7 - 68.5         | 1.94 - 1.94         | 6.204 - 8.082              | 369.094 - 606.462              |
| Total Estimated<br>Withdrawal<br>Volumes/yr. | 2,478.35-3,660.95  | 931.94-1,837.05                  | 174.33-174.33               | 142.49-142.49         | 38,879.80-53,275.40 | 14,566.0- 17,780.0  | 669.45-669.45       | 2,264.46- 2,949.93         | 60,106.82- 80,489.60           |

TABLE 6.3

Estimates of Future Water Demand in the Grand River Basin, 2031

| Sub-Basin Sector                             | Livestock<br>(mgd) | Irrigation<br>Crops/Sod<br>(mgd) | Irrigation<br>Golf<br>(mgd) | Recreational<br>(mgd) | Municipal<br>(mgd)  | Industrial<br>(mgd) | Commercial<br>(mgd) | Domestic<br>Rural<br>(mgd) | Total Water<br>Demand<br>(mgd) |
|----------------------------------------------|--------------------|----------------------------------|-----------------------------|-----------------------|---------------------|---------------------|---------------------|----------------------------|--------------------------------|
| Lower Grand River                            | 0.37 - 1.27        | 18.83 - 44.46                    | 0.39 - 0.39                 | -                     | 30.67 - 51.74       | 26.5 - 33.9         | 0.33 - 0.33         | 1.764 - 2.733              | 78.854 - 134.823               |
| Whiteman Creek                               | 0.35 - 0.44        | 47.54 - 76.86                    | -                           | -                     | -                   | 0.3 - 0.3           | -                   | 0.431 - 0.731              | 48.621 - 78.331                |
| Nith River                                   | 1.89 - 3.08        | 62.22 - 122.73                   | 0.12 - 0.12                 | 0.2 - 0.2             | 3.57 - 5.97         | 10.4 - 13.4         | -                   | 1.274 - 2.137              | 79.494 - 147.457               |
| Paris and Middle<br>Grand River              | 1.64 - 3.81        | 47.14 - 123.35                   | 1.66 - 1.66                 | 2.35 - 2.35           | 105.44 - 180.38     | 30.9 - 53.0         | 1.61 - 1.61         | 2.225 - 4.541              | 192.965 - 370.701              |
| Conestogo River                              | 1.76 - 2.57        | 6.10 - 16.54                     |                             |                       | 0.70 - 1.21         | 8.3 - 10.6          | -                   | 0.933 - 1.958              | 17.793 - 32.878                |
| Upper Grand River                            | 0.69 - 0.75        | 4.51 - 16.91                     |                             |                       | 0.76 - 1.54         | -                   | -                   | 0.432 - 1.371              | 6.392 - 20.571                 |
| Total Estimated<br>Withdrawal Rate           | 6.70 - 11.92       | 186.34 - 400.85                  | 2.17 - 2.17                 | 2.37 - 2.37           | 141.14 - 240.84     | 76.4 - 111.2        | 1.94 - 1.94         | 7.059 - 13.47              | 424.119 - 784.761              |
| Total Estimated<br>Withdrawal<br>Volumes/yr. | 2,478.35-4,350.80  | 931.94-2,004.19                  | 174.33-174.33               | 142.49-142.49         | 51,516.10-87,906.60 | 19,613.0-28,872.0   | 669.45-669.45       | 2,576.50- 4,916.915        | 78,102.16- 129,167.76          |



FIGURE 6.1 SUMMARY OF EXISTING AND ESTIMATED FUTURE  
YEARLY WATER DEMAND BY VOLUME IN THE GRAND RIVER BASIN

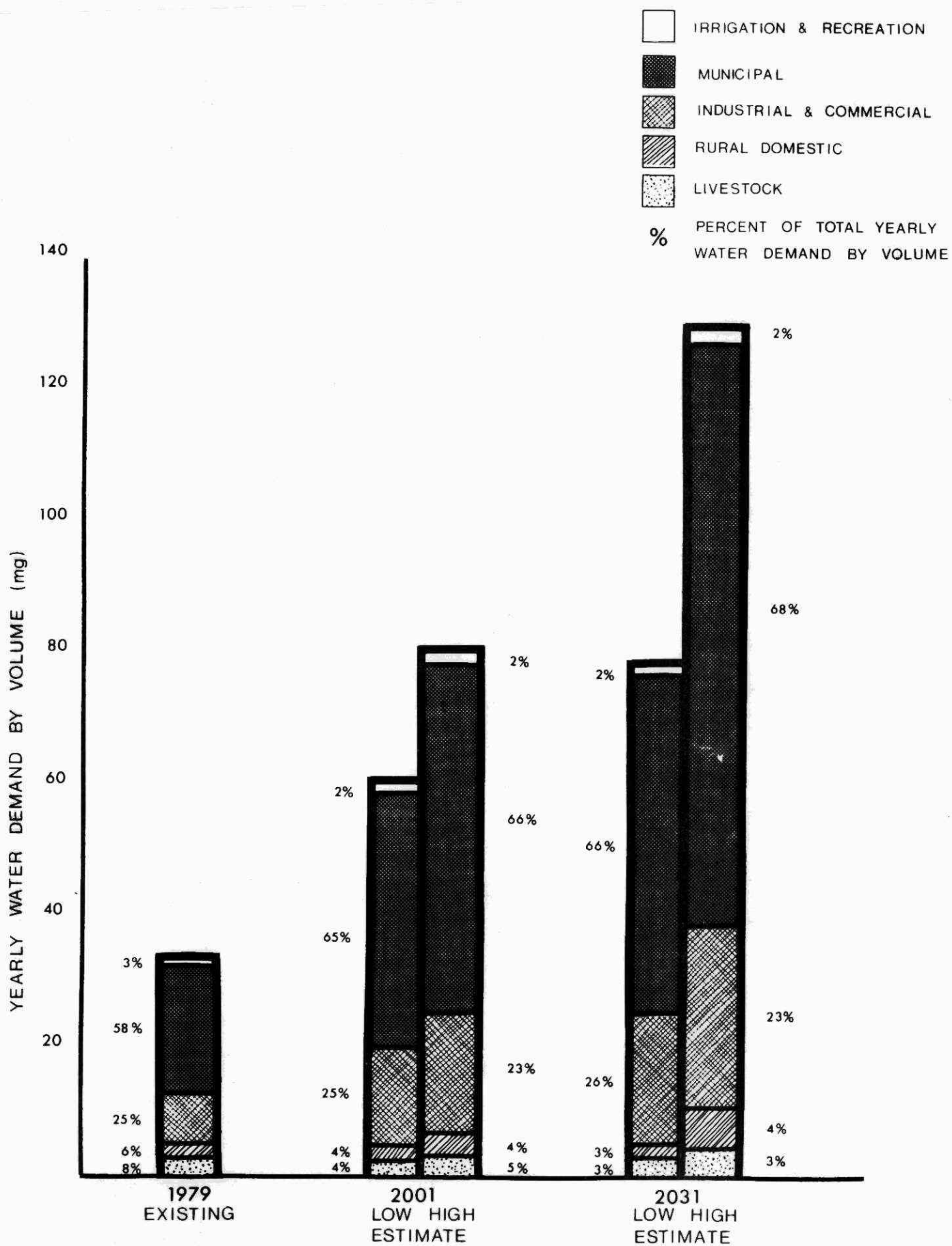
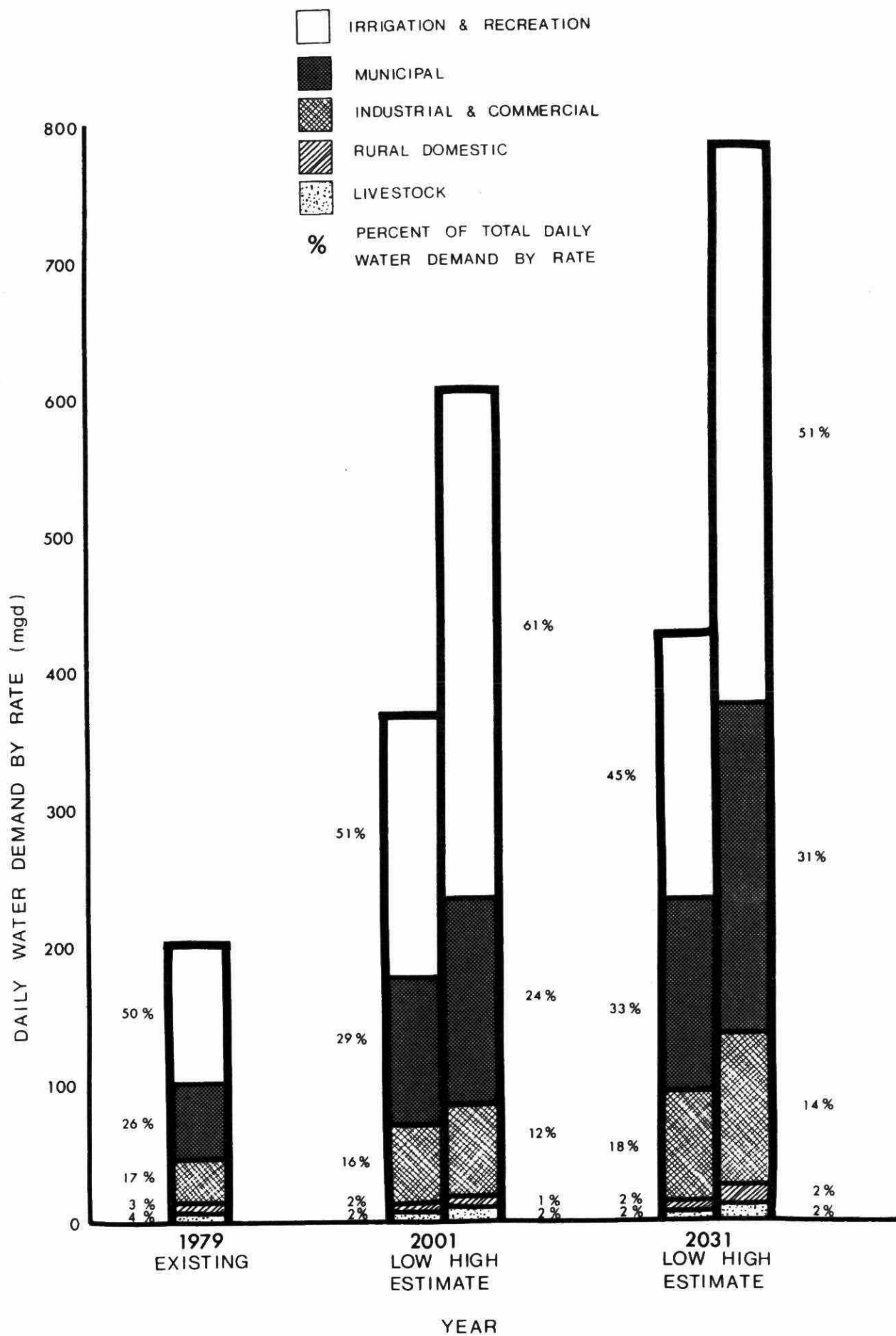


FIGURE 6.2 SUMMARY OF EXISTING AND ESTIMATED FUTURE DAILY WATER DEMAND BY RATE IN THE GRAND RIVER BASIN



Abstraction of water in the central basin to meet projected needs could affect the availability of water for municipal use requiring the implementation of water supply projects before they would otherwise be needed.

Water shortages are not expected in meeting recreational, private commercial, rural domestic or livestock water demand throughout the basin. Water storage may be required for irrigating crops, particularly in the sub-basins of the Conestogo River below the Conestogo dam and the Speed River below Guelph.

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APPENDIX A

MUNICIPAL WATER TAKINGS



## APPENDIX A

### MUNICIPAL WATER-TAKINGS

Appendix A consists of a set of Grand River sub-basin maps which indicates the location of municipal water-takings updated to September 1982. These maps are available for viewing and study at selected basin municipality libraries, the Ministry of the Environment regional offices in London and Hamilton, and the Grand River Conservation Authority in Cambridge.

These maps differentiate various sources of permitted water takings (ie. stream takings, wells, or dugout ponds). The information presented is based on detailed data provided by the Ministry of the Environment. These data, compiled relevant to the sub-basins outlined in Figure 2.2, are summarized in Table 6.1. The locations of permitted municipal water-takings are illustrated in Figures A1.B - A1.M using base maps provided by the Ministry and consequently, sub-basin titles and boundaries vary slightly from those used in the Basin Study. Locations of permitted water-takings are indicated by a permit number which relates to the number of permits located within a particular sub-basin, not the Ministry's file permit number. Detailed information relating to permitted municipal water-takings is available at the Ministry's regional offices.

## APPENDIX B

### URBAN WATER CONSUMPTION DATA FOR THE CITIES OF KITCHENER, WATERLOO, CAMBRIDGE, GUELPH AND BRANTFORD, 1978

## APPENDIX B

### URBAN WATER CONSUMPTION DATA, 1978

#### B1.1 Introduction

This appendix presents a detailed description of municipal water consumption for the five large urban centers within the Grand River basin. The analysis is based on 1978 consumption data, the results of which are outlined in Table B1.1. Section B1.2 provides a general description of methodology and data sources while section B1.3 gives a detailed account of the calculations and assumptions made for each centre.

Although it is preferable to use several years of data to estimate mean consumption rates, the level of detail necessary for the analysis in addition to time constraints limited data collection. However, time series data were investigated for the City of Brantford. The mean per capita consumption net of losses was 114 gpd with a standard deviation of 4 gpd. The 1978 observation deviated from the mean by one standard deviation to give a 3.5% error. In light of the approximations made elsewhere in this analysis, this error seemed acceptable.

Consumption statistics for each community were not derived from uniform sets of raw data. Moreover, some tenuous assumptions were made in order to undertake the analysis. These failings suggest that further work undertaken with these statistics must be interpreted with caution.

TABLE B1.1  
Urban Water Consumption Characteristics

| City                                       | Waterloo  | Kitchener | Guelph    | Brantford | Cambridge | Average |
|--------------------------------------------|-----------|-----------|-----------|-----------|-----------|---------|
| Service Connections                        |           |           |           |           |           |         |
| Residential                                | 11,898    | 28,826    | 14,745    | 19,096    | 18,218    |         |
| Apartment Bldgs.                           | 256       | 819       | 415       | 301       | 289       |         |
| Institutions                               | 70        | 170       | 150       | 140       | 150       |         |
| Commercial                                 | 915       | 1,516     | 1,045     | 1,291     | 839       |         |
| Industrial                                 | 196       | 164       | 193       | 222       | 207       |         |
| Total                                      | 13,335    | 31,495    | 16,548    | 21,050    | 19,703    |         |
| Annual Consumption Breakdown (%)           |           |           |           |           |           |         |
| Residential                                | 31        | 26        | 25        | 26        | 27        | 26      |
| Apartment                                  | 10        | 12        | 9         | 6         | 7         | 9       |
| Institutional                              | 15        | 6         | 13        | 4         | 5         | 10      |
| Commercial                                 | 12        | 10        | 5         | 4         | 15        | 9       |
| Industrial                                 | 20        | 36        | 25        | 40        | 26        | 30      |
| Unaccounted                                | 12        | 10        | 23        | 20        | 20        | 19      |
| Total                                      | 100       | 100       | 100       | 100       | 100       |         |
| 1978 Pumpage<br>(1,000's gal)              | 1,865,855 | 5,037,516 | 3,423,466 | 3,627,851 | 3,054,620 |         |
| Population Served                          | 51,473    | 133,815   | 71,349    | 69,091    | 72,950    |         |
| Total gpd/Capita                           | 99        | 103       | 131       | 143       | 115       | 119     |
| Average Summer Day<br>+ Average Winter Day | 1.12      | 1.17      | 1.15      | 1.28      | 1.12      | 1.17    |
| Maximum Day + Average<br>Day               | 1.65      | 1.55      | 1.70      | 1.61      | 1.54      | 1.62    |
| Residential Consumption<br>(gpd/meter)     |           |           |           |           |           |         |
| Average annual                             | 133       | 126       | 159       | 135       | 124       | 133     |
| Average winter                             | 122       | 106       | 118       | 81        | 112       | 105     |
| Average summer                             | 166       | 176       | 189       | 183       | 155       | 171     |
| Maximum day                                | 381       | 362       | 479       | 419       | 321       | 392     |
| Total Serviced<br>Dwelling Units           | 16,993    | 43,806    | 23,048    | 25,119    | 23,988    |         |
| Persons/Dwelling Unit                      | 3.03      | 3.05      | 3.10      | 2.75      | 3.04      | 2.99    |

## B1.2 General Notes and Assumptions

### (a) Base Year

1978 consumption data and population figures are used throughout this analysis. Information concerning the number of connections, the percentage breakdown of consumption, etc. was obtained from the most recent available year and, where necessary, pro-rated to 1978.

### (b) Institutions

The number of institutional connections was estimated by counting school, church and government addresses listed in 1978 telephone directories.

### (c) Consumption by Apartment Dwellers

A sample of data on apartment consumption was available from Kitchener for two twelve month periods in 1977 and 1978-79. This data was used to estimate an average per unit daily consumption rate of 103 gallons. It was assumed that this rate is constant throughout the year. This assumption is supported by t-tests comparing summer month consumption to winter month consumption; using a one-tail test, no significant difference was found at an 80% level of confidence.

A summary of the analysis of this data is given in Table B1.2.

### (d) Number of Apartment Buildings

Where no information was available on the total number of apartment buildings in a community, the number was estimated by dividing the total number of apartment units by the average number of units per building. Two data sources were used to estimate the average number of units per building. The first was a partial sample of apartment buildings in Waterloo. The second pertained to Kitchener, where data outlining the total number of apartment building service connections were supplied by the city. The number of units was estimated by adding the 1976 census count of apartment

TABLE B1.2  
Tests on Monthly Apartment Consumption in the City of Kitchener

| Period              | Flow (gpd/Apartment) |          | Sample<br>Size (Bldgs.) | t-Tests/F-Tests: |           |        |
|---------------------|----------------------|----------|-------------------------|------------------|-----------|--------|
|                     | Mean                 | St. Dev. |                         | Annual           | Winter    | Summer |
| Annual<br>(1978-79) | 100.1                | 23.0     | 9                       | -                | -         | -      |
| Winter<br>(1978-79) | 100.00               | 21.9     | 9                       | -.0036/1.10      | -         | -      |
| Summer<br>(1978-79) | 100.2                | 27.6     | 9                       | .0087/1.44       | .012/1.59 | -      |
| Annual<br>(1977)    | 102.9                | 37.6     | 13                      | -                | -         | -      |
| Winter<br>(1977)    | 101.04               | 30.12    | 13                      | -.16/1.11        | -         | -      |
| Summer<br>(1977)    | 108.43               | 37.6     | 13                      | .42/1.40         | .57/1.56  | -      |

units to the number of apartment unit completions for the years 1976 and 1977. Unit completion data was obtained from the Canada Mortgage and Housing Corporation (CMHC).

The Waterloo data indicate a value of 25 units per building while the Kitchener data indicate a value of 19 units per building. A weighted average value of 20 units per building was used for the analysis.

#### (e) Seasonal Variability of Consumption

It was assumed that commercial, industrial, apartment and institutional consumption remain constant throughout any given year. The loss, estimated as a percentage of total pumpage, was assumed to vary proportionately with pumpage. The remaining variability was assumed to be caused by domestic consumption. Thus, domestic consumption and losses were assumed to be the cause of high summer pumpage.

The assumption that non-residential consumption does not vary significantly with the seasons is supported by non-residential consumption data from Guelph. Four years of monthly data from 1974 to 1977 were available. Summary statistics for this data are given in Table B1.3. The analysis of seasonal consumption for apartments, given in Table B1.2, provides further support for this assumption.

Table B1.3

Tests on Monthly Industrial Consumption in the City of Guelph, 1974 to 1977

| Period | Flow (1,000's gal/mo) |          | Sample t-Tests/F-Tests<br>Size<br>(Months) | Sample t-Tests/F-Tests |            |        |
|--------|-----------------------|----------|--------------------------------------------|------------------------|------------|--------|
|        | Mean                  | St. Dev. |                                            | Annual                 | Winter     | Summer |
| Annual | 147,339               | 15,987   | 48                                         | -                      | -          | -      |
| Winter | 149,707               | 15,191   | 36                                         | .68/1.05               | -          | -      |
| Summer | 140,234               | 16,866   | 12                                         | -1.34/1.05             | -1.78/1.11 | -      |

One tail t-tests on the various means provided no evidence of significant difference at an 80% level. The summer mean was below the winter mean, contrary to expectations.

(f) Residential Consumption

Residential consumption was considered to be water consumed by individually metered dwelling units. The following formulae are used to estimate domestic consumption per dwelling unit.

$$\begin{aligned}DA &= (TA (1 - L) - I)/N \\DS &= (TS (1 - L) - I)/N \text{ (Summer)} \\DW &= (TW (1 - L) - I)/N \text{ (Winter)} \\DM &= (MAX (1 - L) - I)/N \text{ (Maximum Day)}\end{aligned}$$

where:

TA = total average daily consumption over the year

TS = total average daily consumption over June, July, August

TW = total average daily consumption over the remainder of year

MAX = total maximum day consumption

L = percentage loss

I = average daily non-residential consumption

N = number of domestic connections

DA = domestic average daily consumption over the year

DS = domestic average daily consumption over June, July, August (summer consumption)

DW = domestic average daily consumption over the remainder of year (winter consumption)

(g) Summer Sprinkling Demand

The amount of water used for summer lawn sprinkling was estimated based on observed data for each major urban centre. For the summer months, the sum of the water consumed for industrial, residential, apartment, commercial, and institutional purposes and the water lost through system leakages was



subtracted from the total water consumption figure for each centre. The residual was assumed to be used for summer lawn sprinkling. The results obtained by this method approximated the results obtained by Howe and Linaweaver (1967).

(h) Data References

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personal communication - Canada Mortgage and Housing Corporation (CMHC).
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### B1.3 Forecasting Industrial Water Consumption: A Case Study in "1.6" Analytics

The forecasting of industrial water consumption for those industries linked to a municipal water supply was carried out based on observed data. The following methodology was used to calculate future industrial water consumption in each major centre:

1. Data were collected regarding the industrial water consumption per capita for each major centre (Appendix B1.4)
2. Data were collected describing the amount of water consumed per industrial employee per year for various industrial types (Table B1.4)
3. Forecasts were carried out for the base case and the water conservation case according to the following mathematical equations:

i) Base Case forecasts =  $W \times POP$

where:

$W$  = observed per capita industrial water consumption

$POP$  = forecast population

ii) Water Conservation forecasts =  $[POP_{78} \times W] + [\Delta POP \times W \times F]$

where:

$POP_{78}$  = existing population, 1978

$W$  = observed per capita industrial water consumption

$\Delta POP$  = forecast population increments

$F$  = adjusting factor

NOTE: The water conservation forecasts assume that new per capita industrial consumption falls by a factor, "F", while existing industrial activity remains unchanged in its consumption behaviour.

$$F = [E_i (\text{percentage employment by industry}') \times (\text{industrial consumption rate per employee})] \div [E_i (\text{percentage employment by industry}) \times (\text{industrial consumption rate})]$$

$$= (E_i (P' \times I)) \div (E_i (P \times I)), i = 1 \dots 19$$

where:

$P$  = percentage of total industrial employees in each of 19 industries

$E_i P = 1, i = 1 \dots 19$

$P' = (P \times B) \div E_i P \times B, E_i P' = 1, i = 1 \dots 19$

$B$  = boolean vector where  $b_i = 1$  if industry  $i$  consumes little water

where  $b_i = 0$  if industry  $i$  consumes much water (Table

B1.4)

TABLE B1.4  
Industry Consumption Rates (Great Lakes Region)<sup>1</sup>

| Industry                | Water Consumption/yr Employee<br>(10 <sup>6</sup> U.S. gal) | Boolean Vector |
|-------------------------|-------------------------------------------------------------|----------------|
|                         | I                                                           | B              |
| Food Products           | 0.8031                                                      | 1              |
| Tobacco                 | -                                                           | 1              |
| Textiles                | 0.3389                                                      | 1              |
| Clothing                | 0.00876 <sup>2</sup>                                        | 1              |
| Lumber                  | 1.1388                                                      | 1              |
| Furniture               | 0.136                                                       | 1              |
| Paper Products          | 5.032                                                       | 0              |
| Publishing              | 0.00657 <sup>2</sup>                                        | 1              |
| Chemicals               | 4.9086                                                      | 0              |
| Petroleum               | 12.8167                                                     | 0              |
| Rubber and Plastics     | 0.5371                                                      | 1              |
| Leather                 | 0.4655                                                      | 1              |
| Stone and Clay Products | 1.5482                                                      | 1              |
| Primary Metals          | 8.2602                                                      | 0              |
| Metal Fabricating       | 0.2168                                                      | 1              |
| Machinery               | 0.1366                                                      | 1              |
| Electrical Products     | 0.1226                                                      | 1              |
| Transportation          | 0.2184                                                      | 1              |
| Miscellaneous           | 0.2045                                                      | 1              |

<sup>1</sup>Source: Personal communication, Donald Tate, Environment Canada, 1980.

<sup>2</sup>Source: Forecasting Municipal Water Requirements, Vol. 1, The Main II System, September 1969.

#### B1.4 Detailed Working Notes

##### (A) ANALYSIS OF BRANTFORD WATER CONSUMPTION (1978)

###### (i) RESULTS

###### a) Service Connections

|               |            |
|---------------|------------|
| Residential   | 19,096     |
| Apartment     | 301        |
| Institutional | 140        |
| Commercial    | 1,291      |
| Industrial    | <u>222</u> |
| Total         | 21,050     |

###### b) Annual Consumption Breakdown

|               | Percentage | 1,000's gal.   | 1,000's GPD  |
|---------------|------------|----------------|--------------|
| Residential   | 26         | 943,241        | 2,584        |
| Apartment     | 6          | 217,671        | 596          |
| Institutional | 4          | 145,114        | 398          |
| Commercial    | 4          | 145,175        | 398          |
| Industrial    | 40         | 1,451,140      | 3,976        |
| Unaccounted   | <u>20</u>  | <u>725,510</u> | <u>1,988</u> |
|               | 100        | 3,627,851      | 9,940        |

Population served = 69,091

gpd/capita = 143

###### c) Total Seasonal Consumption

1,000's gpd

|                |        |
|----------------|--------|
| Average winter | 8,645  |
| Average summer | 11,068 |
| Maximum day    | 16,718 |

d) **Unaccounted Seasonal Consumption**

1,000's gpd

|                |       |
|----------------|-------|
| Average winter | 1,729 |
| Average summer | 2,214 |
| Maximum day    | 3,344 |

e) **Residential Seasonal Consumption**

gpd/Meter

|                |     |
|----------------|-----|
| Average annual | 135 |
| Average winter | 81  |
| Average summer | 183 |
| Maximum day    | 419 |

(ii) **ASSUMPTIONS AND NOTES**

a) **Service Connections**

Source of Data

|     |                                                                 |                |                     |
|-----|-----------------------------------------------------------------|----------------|---------------------|
| (1) | 1978 total service connections<br>(net of township connections) | = 21,050       | City of Brantford   |
| (2) | Number of institutions                                          | = 140          | telephone directory |
|     | 1976 apartment units                                            | = 4,775        | 1976 Census         |
|     | 1976-1977 apartment completions                                 | = <u>1,248</u> | CMHC                |
|     | 1978 apartment units                                            | = 6,023        |                     |
| (3) | 1978 apartment<br>buildings = 6,023/20                          | = 301          | by assumption       |
|     | 1976 dwelling units<br>net of apartments                        | = 17,760       | 1976 Census         |
|     | 1976-1977 dwelling unit<br>completions                          | = <u>1,336</u> | CMHC                |
| (4) | 1978 residential connections                                    | = 19,096       |                     |

(5) 1978 commercial and industrial connections

$$(1) - (2) - (3) - (4) = 1,513$$

$$1971 \text{ commercial establishments} = 901$$

1971 Census

$$1971 \text{ industrial establishments} = \underline{155}$$

$$\text{Total} = 1,056$$

assume constant proportions, therefore:

1978 Commercial

$$\text{establishments} = (901/1,056) \times (5) = 1,219$$

1978 Industrial

$$\text{establishments} = (155/1,056) \times (5) = 222$$

b) **Consumption Breakdown**

$$1978 \text{ total pumpage} = 3,627,851,000 \text{ gal.}$$

City of

(net of township sales)

Brantford

$$1978 \text{ total metered sales} = 2,888,496,000 \text{ gal.}$$

$$1978 \text{ unaccounted} = 739,356,000 \text{ gal.}$$

$$= 20\%$$

1978 total apartment consumption =

$$6,023 \text{ units} \times 103 \text{ gpd} \times 365 \text{ days} = 226,435,000 \text{ gal.}$$

By assumption

$$= 6\%$$

1978 consumption by 9 largest

industries

$$= 1,142,445,000 \text{ gal.}$$

City of

$$= 31\%$$

Brantford

1978 consumption by General

Hospital

$$= 74,760,000 \text{ gal.}$$

City of

$$= 2\%$$

Brantford

1978 consumption through

5/8" and 3/4" meters\*

$$= 1,108,756,300 \text{ gal.}$$

City of

$$= 31\%$$

Brantford

1978 consumption through

meter larger than 3/4"

$$= 1,779,754,500 \text{ gal.}$$

City of

$$= 49\%$$

Brantford

## Proposed 1978 Breakdown

By assumption

|              |            |
|--------------|------------|
| Residential  | 26%        |
| Apartment    | 6%         |
| Institutions | 4%         |
| Commercial   | 4%         |
| Industrial   | 40%        |
| Unaccounted  | <u>20%</u> |
|              | 100%       |

### c) Comparison of Consumption Through Time

| Year | Daily          | % Unaccounted<br>Consumption | Net Consumption<br>Per Capita |
|------|----------------|------------------------------|-------------------------------|
| 1971 | 8,523,287 gal. | 20                           | 111 gal.                      |
| 1972 | 8,600,000      | 20.6                         | 106                           |
| 1973 | 8,420,466      | 13.3                         | 112                           |
| 1974 | 8,664,664      | 10.6                         | 119                           |
| 1975 | 8,971,315      | 15.6                         | 116                           |
| 1976 | 9,527,369      | 20.8                         | 113                           |
| 1977 | 10,397,411     | 21.6                         | 118                           |
| 1978 | 10,221,919     | 20.3                         | <u>118</u>                    |
|      |                |                              | mean 114                      |
|      |                |                              | S.D. 4                        |

### d) Large Consumers in Brantford

|                  | Total Consumption<br>(1,000's gal.) | Average Day<br>(1,000's gal.) |
|------------------|-------------------------------------|-------------------------------|
| Harding Carpet   | 182,227                             | 499                           |
| Massey Verity    | 144,949                             | 397                           |
| Diamond National | 77,032                              | 211                           |
| Sunoco           | 62,811                              | 172                           |

|                      |        |     |
|----------------------|--------|-----|
| York Farris          | 61,993 | 170 |
| Massey Heary St.     | 58,206 | 159 |
| Massey Combine       | 52,393 | 144 |
| Hessmann             | 39,048 | 107 |
| Johnson Wax          | 37,964 | 104 |
| B. General Hospital  | 37,038 | 101 |
| White Farm Equipment | 23,491 | 64  |
| Atlas Chemical       | 22,364 | 61  |

Period of consumption 1-79 to 12-79

---

(B) **ANALYSIS OF GUELPH WATER CONSUMPTION (1978)**

(i) **RESULTS**

a) **Service Connections**

|               |            |
|---------------|------------|
| Residential   | 14,745     |
| Apartment     | 415        |
| Institutional | 150        |
| Commercial    | 1,045      |
| Industrial    | <u>193</u> |
| Total         | 16,548     |

b) **Annual Consumption Breakdown**

|               | Percentage | 1,000's Gal.   | 1,000's gpd  |
|---------------|------------|----------------|--------------|
| Residential   | 25         | 855,867        | 2,345        |
| Apartment     | 9          | 308,112        | 844          |
| Institutional | 13         | 445,051        | 1,219        |
| Commercial    | 5          | 171,173        | 469          |
| Industrial    | 25         | 855,867        | 2,345        |
| Unaccounted   | <u>23</u>  | <u>781,835</u> | <u>2,142</u> |
| Total         | 100        | 3,417,905      | 9,364        |



Population served = 71,349  
gpd/capita = 131

c) **Total Seasonal Consumption**

|                |             |
|----------------|-------------|
|                | 1,000's gpd |
| Average Winter | 9,037       |
| Average Summer | 10,396      |
| Maximum Day    | 15,940      |

d) **Unaccounted Seasonal Consumption**

|                |             |
|----------------|-------------|
|                | 1,000's gpd |
| Average Winter | 2,079       |
| Average Summer | 2,391       |
| Maximum Day    | 3,666       |

e) **Residential Seasonal Consumption**

|                |           |
|----------------|-----------|
|                | gpd/Meter |
| Average Annual | 159       |
| Average Winter | 118       |
| Average Summer | 189       |
| Maximum Day    | 479       |

(ii) **ASSUMPTIONS AND NOTES**

a) **Service Connections:**

SOURCE OF DATA

|     |                                     |                |                |
|-----|-------------------------------------|----------------|----------------|
| (1) | 1978 Total Service Connections      | = 16,548       | City of Guelph |
| (2) | 1978 Apartment Units                | = 8,303        | City of Guelph |
| (3) | 1978 Apartment Buildings = 8,303/20 | = 415          |                |
|     | 1976 Total Dwelling Units           | = 22,105       | 1976 Census    |
|     | 1976-1977 Completions               | = <u>1,743</u> | CMHC           |

|     |                                                                       |              |                        |
|-----|-----------------------------------------------------------------------|--------------|------------------------|
| (4) | 1978 Dwelling Units                                                   | = 23,848     |                        |
| (5) | 1978 Non-Serviced Homes<br>(located in recently annexed areas)        | = 800        | By assumption          |
| (6) | 1978 Residential<br>Connections = (4) - (2) - (5)                     | = 14,745     |                        |
| (7) | 1978 Institution Connections                                          | = 150        | Telephone<br>directory |
| (8) | 1978 Commercial and Industrial<br>Connections = (1) - (3) - (6) - (7) | = 1,238      |                        |
|     | 1971 Commercial establishments                                        | = 740        | 1971 Census            |
|     | 1971 Industrial Establishments                                        | = <u>137</u> |                        |
|     | Total                                                                 | = 877        |                        |

Assume constant proportions, therefore:

$$\begin{aligned}
 1978 \text{ Commercial Connections} &= (740/877) \times 1,238 \\
 &= 1,045 \\
 1978 \text{ Industrial Connections} &= (137/877) \times 1,238 \\
 &= 193
 \end{aligned}$$

**b) Consumption Breakdown**

|                    |                      |                |
|--------------------|----------------------|----------------|
| 1978 Total Pumpage | = 3,423,466,000 gal. | City of Guelph |
| 1978 Total Sales   | = 2,641,631,000 gal. |                |
| 1978 Unaccounted   | = 781,835,000 gal.   |                |
|                    | = 23%                |                |

$$\begin{aligned}
 1978 \text{ Apartment Consumption} &= \\
 8,303 \text{ units} \times 103 \text{ gpd} \times 365 \text{ days} &= 312,151,000 \text{ gal.} \quad \text{By assumption} \\
 &= 9\%
 \end{aligned}$$

1978 Consumption by 24

Largest Firms = 629,200,000 gal. City of Guelph\*  
= 18%

1978-79 Consumption by 3 Largest

Institutions = 311,974,000 gal. City of Guelph\*\*  
= 9%

1977 Consumption Sold at Block 1 Rates

= 1,201,026,120 gal. City of Guelph\*\*\*

= 35% of 1977 pumpage

Proposed Breakdown for 1978:

By assumption

|               |     |
|---------------|-----|
| Domestic      | 25% |
| Commercial    | 5%  |
| Industrial    | 25% |
| Institutional | 13% |
| Apartment     | 9%  |
| Loss          | 23% |

\* 12 month period commencing 7/78

\*\* 12 month period commencing 12/78

\*\*\* Primarily residential, commercial, small apartment buildings

c) **Large Consumers in Guelph**

|                                      | Total Consumption<br>(1,000's gal.) | Average Day<br>(1,000's gal.) |
|--------------------------------------|-------------------------------------|-------------------------------|
| Pirelli                              | 324,582                             | 889                           |
| Fiberglas                            | 75,660                              | 207                           |
| Dayton Walther                       | 69,320                              | 190                           |
| Hart Chemical                        | 38,943                              | 107                           |
| Court Galvanizing                    | 26,455                              | 72                            |
| Omark                                | 21,903                              | 60                            |
| C.G.E.                               | 20,789                              | 57                            |
| W. C. Wood                           | 18,206                              | 50                            |
| International Malleable              | 17,469                              | 48                            |
| Imperial Tobacco                     | 16,693                              | 46                            |
| Period of Consumption 7-78 to 6-79   |                                     |                               |
| University of Guelph                 | 269,227                             | 738                           |
| St. Josephs                          | 22,204                              | 61                            |
| General Hospital                     | 20,543                              | 56                            |
| Period of Consumption 12-78 to 11-79 |                                     |                               |

(C) **ANALYSIS OF CAMBRIDGE WATER CONSUMPTION (1978)**

(i) **RESULTS**

a) **Service Connections**

|               |        |
|---------------|--------|
| Residential   | 18,218 |
| Apartment     | 289    |
| Institutional | 150    |

|            |            |
|------------|------------|
| Commercial | 839        |
| Industrial | <u>207</u> |
| Total      | 19,703     |

b) **Annual Consumption Breakdown**

|               | Percentage | 1,000's gal.   | 1,000's GPD  |
|---------------|------------|----------------|--------------|
| Residential   | 27         | 824,748        | 2,260        |
| Apartment     | 7          | 213,823        | 586          |
| Institutional | 5          | 152,731        | 418          |
| Commercial    | 15         | 458,193        | 1,255        |
| Industrial    | 26         | 794,201        | 2,176        |
| Unaccounted   | <u>20</u>  | <u>610,924</u> | <u>1,674</u> |
| Total         | 100        | 3,054,620      | 8,369        |

Population Served = 72,950

Total gpd/capita = 115

c) **Total Seasonal Consumption**

|                | 1,000's gpd |
|----------------|-------------|
| Average Winter | 8,097       |
| Average Summer | 9,078       |
| Maximum Day    | 12,860      |

d) **Unaccounted Seasonal Consumption**

|                | 1,000's gpd |
|----------------|-------------|
| Average Summer | 1,816       |
| Average Winter | 1,619       |
| Maximum Day    | 2,572       |

e) **Residential Seasonal Consumption**

gpd/Meter

|                |     |
|----------------|-----|
| Average Annual | 124 |
| Average Winter | 112 |
| Average Summer | 155 |
| Maximum Day    | 321 |

(ii) **ASSUMPTIONS AND NOTES:**

a) **Service Connections:**

SOURCE OF DATA

(1) 1978 Total Service Connections = 19,703

(2) 1978 Total Residential Connections = 18,218

City  
of  
Cambridge

(3) 1978 Total Non-Residential  
Connections = 1,485  
1976 Apartment Units = 5,335  
1976-1977 Additions = 435  
1978 Apartment Units = 5,770

1976 Census  
CMHC

(4) 1978 Apartment Connections  
= 5,770/20 = 289

By assumption

(5) 1978 Institutional Connections = 150

Telephone  
directory

(6) 1978 Commercial and Industrial  
Connections = (3) - (4) - (5) = 1,046

1971 Commercial Establishments = 759  
1971 Industrial Establishments = 187  
Total = 946

1971  
Census

Assume Constant Proportions, therefore

1978 Industrial Connections =  $(187/946) \times 1,046$   
= 207

1978 Commercial Connections =  $(759/946) \times 1,046$   
= 839

b) **Consumption Breakdown**

|                    |                      |           |
|--------------------|----------------------|-----------|
| 1977 Total Pumpage | = 3,047,157,000 gal. | City      |
| 1977 Total Sales   | = 2,290,479,000 gal. | of        |
| 1977 Unaccounted   | = 756,678,000 gal.   | Cambridge |
|                    | = 25%                |           |

1977 Total Apartment Consumption =  
5,419 units x 103 gpd x 365 days = 203,727,000 gal. By assumption  
= 7%

|                                                       |               |           |
|-------------------------------------------------------|---------------|-----------|
| 1977 Consumption by 9 Largest<br>Industrial Consumers | = 498,955,000 | City of   |
|                                                       | = 16%         | Cambridge |

|                                                       |              |           |
|-------------------------------------------------------|--------------|-----------|
| 1977 Consumption by Largest<br>Institutional Consumer | = 35,770,000 | City of   |
|                                                       | = 1%         | Cambridge |

|                            |                           |
|----------------------------|---------------------------|
| 1975 Consumption Breakdown | Canada Water<br>Inventory |
|----------------------------|---------------------------|

|                 |     |
|-----------------|-----|
| Residential     | 27% |
| Non-Residential | 53% |
| Unaccounted     | 20% |

|                         |               |
|-------------------------|---------------|
| 1978 Proposed Breakdown | By assumption |
|-------------------------|---------------|

|             |     |
|-------------|-----|
| Residential | 27% |
| Apartment   | 7%  |

|               |     |
|---------------|-----|
| Institutional | 5%  |
| Industrial    | 26% |
| Commercial    | 15% |
| Loss          | 20% |

c) **Large Consumers in Cambridge**

|                                     | Total Consumption<br>(1,000's gal.) | Average Day<br>(1,000's gal.) |
|-------------------------------------|-------------------------------------|-------------------------------|
| Canadian General Tower              | 93,805                              | 257                           |
| Hostess Foods                       | 83,950                              | 230                           |
| Galtex                              | 67,160                              | 184                           |
| Babcock - Wilcox                    | 50,005                              | 137                           |
| Dobbie Industries                   | 50,005                              | 137                           |
| Centex                              | 45,260                              | 124                           |
| Galt Malleable Iron                 | 44,165                              | 121                           |
| Franklin Manufacturing              | 39,785                              | 109                           |
| South-Waterloo Memorial Hospital    | 35,770                              | 98                            |
| Long Manufacturing                  | 24,820                              | 68                            |
| Period of Consumption 1-77 to 12-77 |                                     |                               |

(D) **ANALYSIS OF KITCHENER WATER CONSUMPTION (1978)**

(ii) **RESULTS**

a) **Service Connections**

|               |            |
|---------------|------------|
| Residential   | 28,826     |
| Apartment     | 819        |
| Institutional | 170        |
| Commercial    | 1,516      |
| Industry      | <u>164</u> |
| Total         | 31,495     |



b) **Annual Consumption Breakdown**

|               | Percentage | 1,000's gal.   | 1,000's gpd  |
|---------------|------------|----------------|--------------|
| Residential   | 26         | 1,325,048      | 3,630        |
| Apartment     | 12         | 597,911        | 1,638        |
| Institutional | 6          | 255,144        | 699          |
| Commercial    | 10         | 535,475        | 1,467        |
| Industry      | 36         | 1,840,954      | 5,043        |
| Unaccounted   | <u>10</u>  | <u>482,984</u> | <u>1,323</u> |
| Total         | 100        | 5,037,516      | 13,801       |

Population served = 133,815

gpd/capita = 103

c) **Total Seasonal Consumption**

|                | 1,000's gpd |
|----------------|-------------|
| Average Winter | 13,235      |
| Average Summer | 15,482      |
| Maximum Day    | 21,422      |

d) **Unaccounted Seasonal Consumption**

|                | 1,000's gpd |
|----------------|-------------|
| Average Winter | 1,324       |
| Average Summer | 1,548       |
| Maximum Day    | 2,142       |

e) **Residential Seasonal Consumption**

|                | gpd/Meter |
|----------------|-----------|
| Average Annual | 126       |
| Average Winter | 106       |
| Average Summer | 176       |
| Maximum Day    | 362       |

(ii) **ASSUMPTIONS AND NOTES:**

a) **Service Connections 1978**

SOURCE OF DATA

|             |            |
|-------------|------------|
| Residential | 28,826     |
| Commercial  | 1,686      |
| Apartments  | 819        |
| Industry    | <u>164</u> |
| Total       | 31,495     |

City  
of  
Kitchener

Institutional 170  
(component of  
commercial)

Telephone  
Directory

Apartment Units

1976 apartment units = 14,980  
1976-1977 completions = 924  
1978 apartment units = 15,904

1976 Census  
CMHC

b) **Consumption Breakdown**

- (1) 1978 total pumpage = 5,037,516,000 gal.
- (2) 1978 total sales = 4,554,532,000 gal.
- (3) 1978 unaccounted = (1) - (2) = 482,984,000 gal.  
= 10%

City of  
Kitchener

- (4) 1978 apartment consumption  
 14,980 units x 103 gpd x  
 365 days = 597,911,000 gal. By assumption  
 = 12%
- (5) Value of 1978 residential  
 water sales = \$1,060,038 City of  
 Kitchener
- At 85.1¢/1,000 gal. for 0-3,115 gal./month,  
 70.6¢/1,000 gal. for 3,115-105,910 gal./month  
 and 64.2¢/1,000 gal. for 105,911-186,900 gal./month  
 assume an average price of 80¢/1,000 gal.
- (6) 1978 residential consumption = ((5) - .80) x 1,000  
 = 1,325,048,000 gal. By assumption  
 = 26%
- (7) Value of 1978 commercial and city  
 government sales = \$553,433 City of  
 Kitchener  
 at prices given above  
 assume an average price of 70¢/1,000 gal.
- (8) 1978 commercial and government consumption =  
 ((7) - .70) x 1,000 gal. = 790,619,000 gal. By assumption  
 = 16%
- 1978 consumption by two  
 hospitals = 127,572,000 gal. City of  
 = 3% Kitchener
- (9) 1978 institutional  
 consumption = 255,144,000 gal. By assumption  
 = 6%

- (10) 1978 commercial consumption = (8) - (9)  
                                           = 535,475,000 gal.                   By assumption  
                                           = 10%

1978 consumption by 8  
 largest firms                           = 1,218,751,000 gal.                   City of  
                                           = 24%                                           Kitchener

- (11) 1978 industrial consumption = (1)-(3)-(4)-(6)-(8)  
                                           = 1,840,954,000 gal.  
                                           = 36%

c) **Large Consumers in Cambridge**

|                               | Total Consumption<br>(1,000's gal.) | Average Day<br>(1,000's gal.) |
|-------------------------------|-------------------------------------|-------------------------------|
| J. M. Schneider               | 444,122                             | 1,217                         |
| Burns Meats                   | 135,281                             | 371                           |
| B. F. Goodrich (521 King W.)  | 99,897                              | 274                           |
| K. W. Hospital                | 96,625                              | 265                           |
| Uniroyal (51 Breithaupt)      | 87,221                              | 239                           |
| B. F. Goodrich (Goodrich Dr.) | 80,884                              | 222                           |
| Uniroyal (149 Strange)        | 79,754                              | 219                           |
| Robson-Lang Leathers          | 62,662                              | 172                           |
| Lear Siegler Ind.             | 61,103                              | 167                           |
| Uniroyal (84 Margaret)        | 59,793                              | 164                           |
| Budd Automotive Co.           | 34,377                              | 94                            |
| St. Mary's Hospital           | 30,937                              | 85                            |
| Lear Siegler (Ottawa St.)     | 23,901                              | 65                            |
| Kaufman Footwear              | 11,501                              | 32                            |
| Electrohome                   | 11,481                              | 31                            |

Period of consumption 10-78 to 9-79

(E) ANALYSIS OF WATERLOO WATER CONSUMPTION (1978)

(i) RESULTS

a) Service Connections

|               |            |
|---------------|------------|
| Residential   | 11,898     |
| Apartment     | 256        |
| Institutional | 70         |
| Commercial    | 915        |
| Industrial    | <u>196</u> |

Total 13,335

b) Annual Consumption Breakdown

|               | Percentage | 1,000's gal.   | 1,000's gpd |
|---------------|------------|----------------|-------------|
| Residential   | 31         | 578,415        | 1,585       |
| Apartment     | 10         | 186,586        | 511         |
| Institutional | 15 57      | 279,878        | 767 2,913   |
| Commercial    | 12         | 223,903        | 613         |
| Industrial    | 20         | 373,171        | 1,022       |
| Unaccounted   | <u>12</u>  | <u>223,903</u> | <u>613</u>  |
| Total         | 100        | 1,865,865      | 5,111       |

Population served = 51,473

gpd/capita = 99

c) **Total Seasonal Consumption**

1,000's gpd

|                |       |
|----------------|-------|
| Average Winter | 4,961 |
| Average Summer | 5,559 |
| Maximum Day    | 8,457 |

d) **Unaccounted Seasonal Consumption**

1,000's gpd

|                |       |
|----------------|-------|
| Average Winter | 594   |
| Average Summer | 672   |
| Maximum Day    | 1,015 |

e) **Residential Consumption**

gpd/Meter

|                |     |
|----------------|-----|
| Average Annual | 133 |
| Average Winter | 122 |
| Average Summer | 166 |
| Maximum Day    | 381 |

(ii) **ASSUMPTIONS AND NOTES:**

a) **Service Connections**

SOURCE OF DATA

(1) 1978 total service connections = 13,335

City of  
Waterloo

1976 dwelling units net of  
apartments = 10,315

1976 Census

1976-1977 dwelling unit  
completions = 1,583

CMHC

(2) 1978 residential connections = 11,898

1976 apartment units = 5,095  
 1976-1977 apartment completions = 21

1976 Census  
 CMHC

(3) 1978 apartment units = 5,116

(4) 1978 apartment building  
 connections 5,116/20 = 256

By assumption

(5) 1978 institution connections = 70

Telephone  
 directory

(6) 1978 industrial and commercial  
 connections (1)-(2)-(4)-(5) = 1,111

1971 industrial establishments = 83

1971 Census

1971 commercial establishments = 388

Total = 471

assume constant proportions therefore

(7) 1978 industrial connections = (83/471)1,111  
 = 196

(8) 1978 commercial connections = (388/471)1,111  
 = 915

#### b) Consumption Breakdown

1978 total pumpage = 1,865,855,000 gal.

1978 residential water sales  
 revenue

= \$303,281.29

City  
 of

1978 non-residential water  
 sales revenue

= \$563,128.62

Waterloo

Water price = \$.53/1,000 gal.

Residential consumption = 30,328,129/53  
= 572,228,849 gal.  
= 31%

Non-residential consumption = 56,312,862/53  
= 1,062,506,830 gal.  
= 57%

These categories include consumption by apartments: By  
5,116 units x 103 gpd/unit x 365 days = 19,233,600 assumption  
= 10%

1978 consumption by universities = 178,850,000 gal. City of  
= 9% Waterloo

1978 consumption by 8 largest  
firms = 228,855,000 gal. City of  
= 12% Waterloo

1975 consumption breakdown: Canada  
Domestic 30% Water  
Commercial 10% Inventory  
Industrial 35%  
Institutional 15%  
Loss 10%

Proposed breakdown for 1978:

Domestic 31%  
Commercial 12%  
Industrial 20%  
Apartment 10%  
Institutional 15%  
Loss 12%



c) **Large Consumers in Waterloo**

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|                            | Total Consumption<br>(1,000's gal.) | Average Day<br>(1,000's gal.) |
|----------------------------|-------------------------------------|-------------------------------|
| <hr/>                      |                                     |                               |
| University of Waterloo     | 164,250                             | 450                           |
| Labatt's Brewery           | 129,210                             | 354                           |
| Leigh Industries           | 41,975                              | 115                           |
| Kraus Carpets              | 24,090                              | 66                            |
| Richmond Square            | 16,425                              | 45                            |
| Wilfrid Laurier University | 14,600                              | 40                            |
| Bauer Industries           | 6,205                               | 17                            |
| Sunar Industries           | 4,745                               | 13                            |
| Mutual Life                | 4,745                               | 13                            |
| Marsland Centre            | 1,460                               | 4                             |

Period of consumption 1-78 to 12-78

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## APPENDIX C

### ESTIMATION OF DWELLING UNIT TYPES FOR WATER DEMAND PROJECTIONS

## APPENDIX C

### ESTIMATION OF DWELLING UNIT TYPES FOR WATER DEMAND PROJECTIONS

#### C1.1 Introduction

This appendix presents a methodology for prediction of the mix of dwelling types in urban areas based on forecast population levels. The methodology was developed for use in the study of urban water demand within the Grand River basin. Regression analysis was used to identify a functional relationship between the mix of dwelling types and populations.

#### C1.2 Functional Relationship

Since residential consumption of water varies with the type of residential dwelling unit, it is necessary to distinguish between apartment units and detached, semi-detached and attached units. Consumption patterns of apartment dwellers may differ from other groups for two reasons: apartments are not usually metered individually so that apartment dwellers do not pay directly for water consumed; and since apartment dwellers do not tend any lawn area, the seasonal variation of their consumption is not as great. In a water demand study, it is also useful to differentiate between the three types of non-apartment dwelling units. Detached, semi-detached and attached dwelling units generally are built on varying lot sizes, with detached homes on the largest lots. Lot size will determine lawn area and therefore the likely contribution of each dwelling unit to summer sprinkling water demand.

The dependant variables in this study are the proportion of dwelling units in the community that are apartment units (A), the proportion of non-apartment units that are attached units (R), and the proportion of non-apartment units that are semi-detached (S). These variables measure housing density, a characteristic or dimension of housing that is determined in part in the market for housing. The supply side of this market depends on land costs, construction costs, and other costs. Construction costs were assumed to be similar across southern Ontario and since the data base is cross-sectional, it was legitimate to ignore these costs. Land prices

reflect a community's geographic location, its economic base, its size, etc. Population size (P) was used as a proxy to measure these factors. Two variables were used to measure the impact of demand on housing density. These are the income level (Y) of the population, and the average family size (F) in the community. General expressions for the reduced form equation of this model of the market are:

$$A = f(P,F,Y), R = g(P,F,Y), S = d(P,F,Y)$$

where f, g and d designate unspecified functional forms.

### C1.3 Data

Forty-five communities from the southern half of Ontario were included in the sample. Population and dwelling type data were obtained for 1976 from the 1976 Census report "Population: Geographic Distribution" (catalogue number 92-810). A measure of average income per household was based on the total income reported on taxable income tax returns filed in each community in 1977. This data was obtained from the Revenue Canada publication, "Taxation Statistics - 1977". This measure of income was divided by the total number of dwelling units reported in the census for each community in order to get a measure of income per dwelling unit. Descriptive statistics for these variables are given in Table C1.1.

TABLE C1.1  
Sample Data

| Variable | Description                                   | Mean   | Standard<br>Deviation | Simple Correlations |       |       |
|----------|-----------------------------------------------|--------|-----------------------|---------------------|-------|-------|
|          |                                               |        |                       | P                   | F     | Y     |
| A        | Apartment Units/<br>Total D.U.*               | .216   | .096                  | .532                | -.482 | .475  |
| R        | Attached Units/<br>Total D.U.-Apts.           | .141   | .081                  | .387                | .192  | .455  |
| S        | Semi-Detached Units/<br>Total D.U.-Apts.      | .061   | .032                  | -.059               | -.628 | -.122 |
| P        | Population<br>(10 <sup>4</sup> persons)       | 10.781 | 31.877                | 1.0                 | -.113 | .150  |
| F        | Family Size<br>(Persons/D.U.)                 | 3.096  | .202                  | --                  | 1.0   | .051  |
| Y        | Household Income<br>(\$10 <sup>5</sup> /D.U.) | .205   | .041                  | --                  | --    | 1.0   |

\*D.U. = Dwelling Unit

#### C1.4 Results

Linear and non-linear relationships were tested. Five of these tests are reported below:

$$(1) \quad A = .640 + .022 (p^{.5}) - .213 F + .890 Y$$

(6.14)                      (-5.49)                      (4.53)

$$r^2 = 73.26, F = 37.43, n = 45$$

$$(2) \quad A = .670 + .001 P - .219 F + 1.035 Y$$

(4.41)                      (-4.96)                      (4.71)

$$r^2 = 65.2, F = 25.6, n = 45$$

$$(3) \quad \ln(A) = 3.355 + .181 \ln(P) - 3.551 \ln(F) + .758 \ln(Y)$$

(4.80)                      (-5.21)                      (3.75)

$$r^2 = 66.34, F = 26.94, n = 45$$

$$(4) \quad \ln(S) = 4.865 - 7.715 \ln(F) + .524 \ln(Y)$$

(-6.10)                      (-1.46)

$$r^2 = 48.73, F = 20.12, n = 45$$

$$(5) \quad \ln(R) = -1.763 + .176 \ln(P) + .990 \ln(F) + 1.054 \ln(Y)$$

(3.14)                      (.98)                      (3.51)

$$r^2 = 43.68, F = 10.6, n = 45$$

In the first three equations which deal with apartment units, the variables are always significant and the signs on the coefficients are robust. All three equations give very similar results as can be seen in Figure C1.1 below. Equation (1) seems to give the best fit and was selected for further work in this study.

For attached and semi-attached units, the regressions results were considerably weaker. This is evident from the  $r^2$  and F values. Functional forms like those in the first three equations were tested, but only the best equations are presented here. A very low t-score prompted the exclusion of the variable P from equation (4).

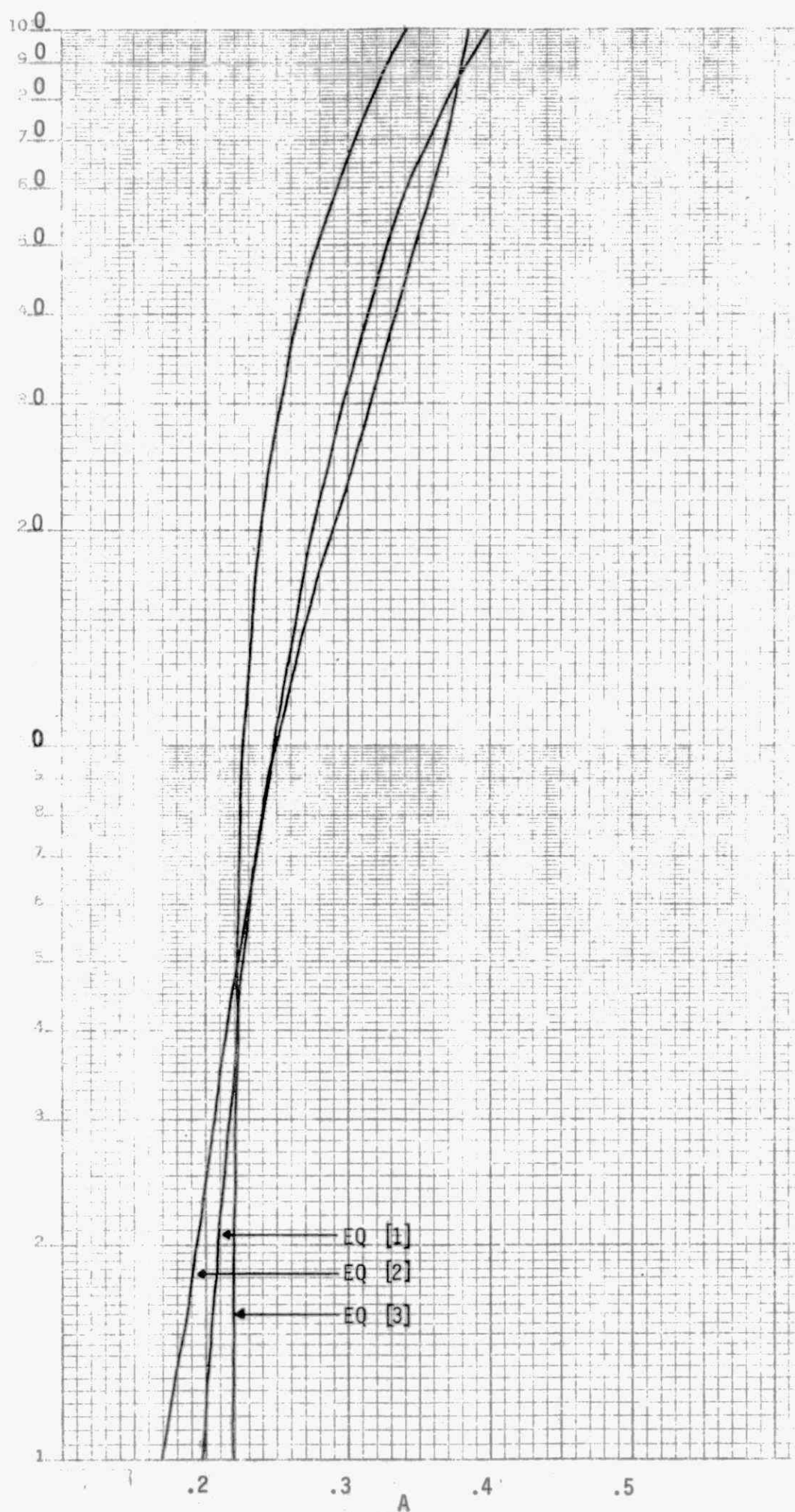


Figure C1.1 Regression Results For  $A=f(P,Y,F)$ ,  $Y=.2$ ,  $F=3$

The projections in Table C1.2 were made with equations (1), (4) and (5). The proportion of detached units was estimated as a residual once the three values for the other types of units were determined. For these projections, 1976 income levels were used. A range of population projections were available and a single projection of family size was used for all cities. This projection predicted a fall in family size from 3.1 in 1976 to 2.6 by 2001 and a stable size thereafter. Generally, the figures in Table C1.2 foretell a dramatic shift from detached units to semi-detached and apartment units. The assumed fall in family size is a critical factor determining this reallocation.



TABLE C1.2  
Projections of the Mix of Dwelling Units

| Community           | Kitchener/Waterloo |     |     |      | Cambridge |     |     |      | Guelph |     |      | Brantford |     |      |
|---------------------|--------------------|-----|-----|------|-----------|-----|-----|------|--------|-----|------|-----------|-----|------|
| Population Forecast | "Low Low"          | Low | Med | High | "Low Low" | Low | Med | High | Low    | Med | High | Low       | Med | High |
| % of Detached Units |                    |     |     |      |           |     |     |      |        |     |      |           |     |      |
| 1976                | 51                 | 51  | 51  | 51   | 57        | 57  | 57  | 57   | 55     | 55  | 55   | 61        | 61  | 61   |
| 2001                | 35                 | 34  | 34  | 33   | 39        | 39  | 39  | 38   | 39     | 38  | 38   | 44        | 44  | 43   |
| 2031                | 34                 | 33  | 31  | 31   | 38        | 38  | 37  | 37   | 38     | 36  | 34   | 43        | 42  | 41   |
| % Apartments        |                    |     |     |      |           |     |     |      |        |     |      |           |     |      |
| 1976                | 34                 | 34  | 34  | 34   | 24        | 24  | 24  | 24   | 20     | 30  | 30   | 21        | 21  | 21   |
| 2001                | 47                 | 47  | 48  | 48   | 36        | 36  | 36  | 36   | 41     | 42  | 42   | 33        | 33  | 33   |
| 2031                | 47                 | 48  | 50  | 51   | 36        | 36  | 38  | 38   | 42     | 44  | 46   | 34        | 35  | 36   |
| % Semi-Detached     |                    |     |     |      |           |     |     |      |        |     |      |           |     |      |
| 1976                | 5                  | 5   | 5   | 5    | 6         | 6   | 6   | 6    | 3      | 3   | 3    | 8         | 8   | 8    |
| 2001                | 11                 | 11  | 11  | 11   | 15        | 15  | 15  | 15   | 11     | 11  | 11   | 16        | 16  | 16   |
| 2031                | 11                 | 11  | 11  | 10   | 15        | 15  | 14  | 14   | 11     | 10  | 10   | 16        | 16  | 16   |
| % Attached Units    |                    |     |     |      |           |     |     |      |        |     |      |           |     |      |
| 1976                | 11                 | 11  | 11  | 11   | 13        | 13  | 13  | 13   | 12     | 12  | 12   | 9         | 9   | 9    |
| 2001                | 8                  | 8   | 8   | 8    | 11        | 11  | 11  | 11   | 9      | 9   | 9    | 7         | 7   | 7    |
| 2031                | 8                  | 8   | 8   | 8    | 11        | 11  | 11  | 11   | 9      | 10  | 10   | 7         | 7   | 8    |

## APPENDIX D

### INDUSTRIAL AND COMMERCIAL WATER TAKINGS

## APPENDIX D

### INDUSTRIAL AND COMMERCIAL WATER-TAKINGS

Appendix D consists of a set of Grand River sub-basin maps which indicates the location of industrial and commercial water-takings updated to September 1982. These maps are available for viewing and study at selected basin municipality libraries, the Ministry of the Environment regional offices in London and Hamilton, and the Grand River Conservation Authority in Cambridge.

These maps differentiate various sources of permitted water takings (ie. stream takings, wells, or dugout ponds). The information presented is based on detailed data provided by the Ministry of the Environment. These data, compiled relevant to the sub-basins outlined in Figure 2.2, are summarized in Table 6.1. The locations of permitted industrial and commercial water-takings are illustrated in Figures D1.A - D1.L using base maps provided by the Ministry and consequently, sub-basin titles and boundaries vary slightly from those used in the Basin Study. Locations of permitted water-takings are indicated by a permit number which relates to the number of permits located within a particular sub-basin, not the Ministry's file permit number. Detailed information relating to permitted industrial and commercial water-takings is available at the Ministry's regional offices.

APPENDIX E

IRRIGATION WATER TAKINGS  
AND RECREATIONAL STORAGE PONDS

## APPENDIX E

### IRRIGATION WATER-TAKINGS AND RECREATIONAL STORAGE PONDS

Appendix E consists of a set of Grand River sub-basin maps which indicates the location of irrigation water-takings and recreational storage ponds updated to September 1982. These maps are available for viewing and study at selected basin municipality libraries, the Ministry of the Environment regional offices in London and Hamilton, and the Grand River Conservation Authority in Cambridge.

These maps differentiate various sources of permitted water takings (ie. stream takings, wells, or dugout ponds) and specific irrigation use (ie. market garden, tobacco, sod, golf, or recreation). The information presented is based on detailed data provided by the Ministry of the Environment. These data, compiled relevant to the sub-basins outlined in Figure 2.2, are summarized in Table 6.1. The locations of permitted irrigation water-takings and recreational storage ponds are illustrated in Figures E1.A - A1.J using base maps provided by the Ministry and consequently, sub-basin titles and boundaries vary slightly from those used in the Basin Study. Locations of permitted water-takings are indicated by a permit number which relates to the number of permits located within a particular sub-basin, not the Ministry's file permit number. Detailed information relating to permitted irrigation water-takings and recreational storage ponds is available at the Ministry's regional offices.

## APPENDIX F

### WATER DEMAND PROJECTIONS FOR AGRICULTURAL IRRIGATION 2001 AND 2031

TABLE F1.1  
Estimated Water Demand for Irrigation - Scenario 1

| Sector                                  | Associated Sub-Basins                                                                   | Total Area<br>of Sector<br>(acres) | Estimated Area of Soils<br>In Sand/Sandy Loam |                | Projected Area of<br>Corn (acres) |         | Other Row Crops<br>(acres) |        | Projected Area of<br>(acres) |        |       |      | Estimated Area<br>Requiring Irrigation |          |       |       | Estimated Water Demand (mg)* |      |
|-----------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------|-----------------------------------------------|----------------|-----------------------------------|---------|----------------------------|--------|------------------------------|--------|-------|------|----------------------------------------|----------|-------|-------|------------------------------|------|
|                                         |                                                                                         |                                    | Acres                                         | % of Sub Basin | 2001                              | 2031    | 2001                       | 2031   | Corn                         |        | Other |      | Corn                                   |          | Other |       | 2001                         | 2031 |
|                                         |                                                                                         |                                    |                                               |                |                                   |         |                            |        | 2001                         | 2031   | 2001  | 2031 | 2001                                   | 2031     | 2001  | 2031  |                              |      |
|                                         |                                                                                         |                                    |                                               |                |                                   |         |                            |        |                              |        |       |      |                                        |          |       |       |                              |      |
|                                         |                                                                                         |                                    |                                               |                |                                   |         |                            |        |                              |        |       |      |                                        |          |       |       |                              |      |
| <u>Upper Grand River</u>                |                                                                                         |                                    |                                               |                |                                   |         |                            |        |                              |        |       |      |                                        |          |       |       |                              |      |
| a) Grand River above Lake Belwood       | GA0101; GA0102                                                                          | 170,178                            | 3,404                                         | 2              | 14,440                            | 25,495  | 237                        | 237    | 289                          | 510    | 5     | 5    | 19.51                                  | 34.43    | 0.29  | 0.29  |                              |      |
| b) Grand River above Shand Dam          | GA0103                                                                                  | 33,098                             | 1,792                                         | 5              | 9,154                             | 14,756  | 0                          | 0      | 458                          | 738    | 0     | 0    | 30.92                                  | 49.82    | 0     | 0     |                              |      |
| Total                                   |                                                                                         | 203,276                            | 5,196                                         | 2.6            | 23,594                            | 40,251  | 237                        | 237    | 747                          | 1,248  | 5     | 5    | 50.43                                  | 84.25    | 0.29  | 0.29  |                              |      |
| <u>Conestogo River</u>                  |                                                                                         |                                    |                                               |                |                                   |         |                            |        |                              |        |       |      |                                        |          |       |       |                              |      |
| a) Conestogo River above Conestogo Lake | GA0601                                                                                  | 68,436                             | 691                                           | 1              | 10,391                            | 18,100  | 0                          | 0      | 104                          | 181    | 0     | 0    | 7.02                                   | 12.22    | 0     | 0     |                              |      |
| b) Conestogo River above Conestogo Dam  | GA0602                                                                                  | 71,208                             | 666                                           | 1              | 21,430                            | 37,334  | 0                          | 0      | 214                          | 373    | 0     | 0    | 14.45                                  | 25.18    | 0     | 0     |                              |      |
| c) Conestogo River below Conestogo Dam  | GA0603; GA0604                                                                          | 65,608                             | 1,101                                         | 2              | 27,479                            | 33,350  | 240                        | 240    | 550                          | 667    | 5     | 5    | 37.13                                  | 45.02    | 0.29  | 0.29  |                              |      |
| Total                                   |                                                                                         | 205,252                            | 2,458                                         | 1.2            | 59,300                            | 88,784  | 240                        | 240    | 868                          | 1,221  | 5     | 5    | 58.60                                  | 82.42    | 0.29  | 0.29  |                              |      |
| <u>Middle Grand River</u>               |                                                                                         |                                    |                                               |                |                                   |         |                            |        |                              |        |       |      |                                        |          |       |       |                              |      |
| a) Grand River above West Montrose      | GA0104                                                                                  | 90,777                             | 3,360                                         | 3.7            | 46,041                            | 53,152  | 0                          | 0      | 1,842                        | 2,126  | 0     | 0    | 124.34                                 | 143.51   | 0     | 0     |                              |      |
| b) Canagagigue Creek                    | GA0105; GA0106                                                                          | 26,580                             | 1,049                                         | 3.9            | 11,268                            | 11,268  | 0                          | 0      | 451                          | 451    | 0     | 0    | 30.44                                  | 30.44    | 0     | 0     |                              |      |
| c) Speed River above Guelph             | GA0401; GA0402                                                                          | 68,797                             | 11,187                                        | 16.0           | 31,453                            | 31,453  | 203                        | 203    | 5,032                        | 5,032  | 33    | 33   | 339.66                                 | 339.66   | 1.88  | 1.88  |                              |      |
| d) Speed River below Guelph             | GA0403; GA0404; GA0405;<br>GA0406; GA0407; GA0408                                       | 56,753                             | 3,507                                         | 6.0            | 13,204                            | 13,204  | 205                        | 205    | 792                          | 792    | 12    | 12   | 53.46                                  | 53.46    | 0.68  | 0.68  |                              |      |
| e) Eramosa River above Guelph           | GA05                                                                                    | 65,467                             | 1,715                                         | 3.0            | 12,459                            | 15,929  | 0                          | 0      | 374                          | 478    | 0     | 0    | 25.25                                  | 32.27    | 0     | 0     |                              |      |
| f) Galt Creek                           | GA0301; GA0302; GA0303;<br>GA0304                                                       | 24,517                             | 160                                           | 0.7            | 3,248                             | 3,305   | 0                          | 0      | 23                           | 23     | 0     | 0    | 1.55                                   | 1.55     | 0     | 0     |                              |      |
| g) Grand River above Cambridge          | GA0107; GA0108; GA0109;<br>GA0110                                                       | 125,903                            | Insufficient Data                             |                | 34,012                            | 34,012  | 622                        | 622    | -                            | -      | -     | -    | -                                      | -        | -     | -     |                              |      |
| Total                                   |                                                                                         | 458,804                            | 20,978                                        | 4.6            | 151,685                           | 162,413 | 1,030                      | 1,030  | 8,514                        | 8,902  | 45    | 45   | 574.7                                  | 600.89   | 2.56  | 2.56  |                              |      |
| <u>Paris</u>                            |                                                                                         |                                    |                                               |                |                                   |         |                            |        |                              |        |       |      |                                        |          |       |       |                              |      |
|                                         | GA0111                                                                                  | 23,754                             | 640                                           | 3.0            | 6,889                             | 6,889   | 0                          | 0      | 207                          | 207    | 0     | 0    | 13.97                                  | 13.97    | 0     | 0     |                              |      |
| <u>Nith River</u>                       |                                                                                         |                                    |                                               |                |                                   |         |                            |        |                              |        |       |      |                                        |          |       |       |                              |      |
|                                         | GA0201; GA0202; GA0203;<br>GA0204; GA0205; GA0206;<br>GA0207; GA0208; GA0209;<br>GA0210 | 283,104                            | 20,633                                        | 7.3            | 112,481                           | 128,144 | 2,045                      | 2,045  | 7,847                        | 8,970  | 143   | 143  | 531.50                                 | 605.48   | 8.15  | 8.15  |                              |      |
| <u>Whiteman Creek</u>                   |                                                                                         |                                    |                                               |                |                                   |         |                            |        |                              |        |       |      |                                        |          |       |       |                              |      |
|                                         | GB0501; GB0502                                                                          | 100,662                            | 12,749                                        | 12.7           | 44,332                            | 44,332  | 5,528                      | 5,528  | 5,320                        | 5,320  | 442   | 442  | 359.10                                 | 359.10   | 25.19 | 25.19 |                              |      |
| <u>Lower Grand River</u>                |                                                                                         |                                    |                                               |                |                                   |         |                            |        |                              |        |       |      |                                        |          |       |       |                              |      |
| a) Fairchild and Big Creek              | GB04; GB03                                                                              | 145,249                            | 973                                           | 0.7            | 45,080                            | 45,080  | 2,040                      | 2,040  | 316                          | 316    | 14    | 14   | 21.33                                  | 21.33    | 0.80  | 0.80  |                              |      |
| b) McKenzie Creek                       | GB0201                                                                                  | 50,134                             | 2,919                                         | 5.8            | 13,232                            | 14,007  | 2,423                      | 2,423  | 794                          | 840    | 121   | 121  | 53.60                                  | 56.70    | 6.90  | 6.90  |                              |      |
| c) Boston Creek                         | GB0202                                                                                  | 57,015                             | 1,101                                         | 1.9            | 19,548                            | 25,523  | 1,442                      | 1,442  | 391                          | 510    | 29    | 29   | 26.39                                  | 34.43    | 1.65  | 1.65  |                              |      |
| d) Grand River below Brantford          | GB0101; GB0102; GB0103                                                                  | 194,826                            | 6,336                                         | 3.3            | 48,733                            | 54,234  | 2,537                      | 2,537  | 1,462                        | 1,627  | 51    | 51   | 98.69                                  | 109.82   | 2.91  | 2.91  |                              |      |
| Total                                   |                                                                                         | 447,224                            | 11,329                                        | 2.5            | 126,593                           | 138,844 | 8,442                      | 8,442  | 2,963                        | 3,299  | 215   | 215  | 200.01                                 | 222.28   | 12.26 | 12.26 |                              |      |
| Total Watershed                         |                                                                                         | 1,722,076                          | 73,983                                        | 4.3            | 524,874                           | 609,657 | 17,522                     | 17,522 | 26,466                       | 29,161 | 855   | 855  | 1,788.31                               | 1,968.39 | 48.74 | 48.74 |                              |      |

\*Calculated for a 92 day period from June 1 to August 31.

TABLE F1.2  
Estimated Water Demand for Irrigation - Scenario 2

| Sector                                  | Associated Sub-Basins                                                                   | Total Area<br>of Sector<br>(acres) | Estimated Area of Soils<br>In Sand/Sandy Loam |                | Projected Area of<br>Corn (acres) |         | Projected Area of<br>Other Row Crops<br>(acres) |        | Estimated Area<br>Requiring Irrigation<br>(acres) |        |       |      | Estimated Water Demand (mg)* |          |       |       |  |
|-----------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------|-----------------------------------------------|----------------|-----------------------------------|---------|-------------------------------------------------|--------|---------------------------------------------------|--------|-------|------|------------------------------|----------|-------|-------|--|
|                                         |                                                                                         |                                    | Acres                                         | % of Sub Basin | 2001                              | 2031    | 2001                                            | 2031   | Corn                                              |        | Other |      | Corn                         |          | Other |       |  |
|                                         |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        | 2001                                              | 2031   | 2001  | 2031 | 2001                         | 2031     | 2001  | 2031  |  |
| <u>Upper Grand River</u>                |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        |                                                   |        |       |      |                              |          |       |       |  |
| a) Grand River above Lake Belwood       | GA0101; GA0102                                                                          | 170,178                            | 3,404                                         | 2              | 14,440                            | 25,495  | 237                                             | 237    | 289                                               | 510    | 5     | 5    | 19.51                        | 34.43    | 0.29  | 0.29  |  |
| b) Grand River above Shand Dam          | GA0103                                                                                  | 33,098                             | 1,792                                         | 5              | 9,154                             | 12,093  | NIL                                             | NIL    | 458                                               | 605    | NIL   | NIL  | 30.92                        | 40.84    | NIL   | NIL   |  |
| Total                                   |                                                                                         | 203,276                            | 5,196                                         | 2.6            | 23,594                            | 37,588  | 237                                             | 237    | 747                                               | 1,115  | 5     | 5    | 50.43                        | 75.27    | 0.29  | 0.29  |  |
| <u>Conestogo River</u>                  |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        |                                                   |        |       |      |                              |          |       |       |  |
| a) Conestogo River above Conestogo Lake | GA0601                                                                                  | 68,436                             | 691                                           | 1              | 10,391                            | 18,100  | NIL                                             | NIL    | 104                                               | 181    | NIL   | NIL  | 7.02                         | 12.22    | NIL   | NIL   |  |
| b) Conestogo River above Conestogo Dam  | GA0602                                                                                  | 71,208                             | 666                                           | 1              | 21,430                            | 37,334  | NIL                                             | NIL    | 214                                               | 373    | NIL   | NIL  | 14.45                        | 25.18    | NIL   | NIL   |  |
| c) Conestogo River below Conestogo Dam  | GA0603; GA0604                                                                          | 65,608                             | 1,101                                         | 2              | 10,845                            | 10,845  | 240                                             | 240    | 217                                               | 217    | 5     | 5    | 14.65                        | 14.65    | 0.29  | 0.29  |  |
| Total                                   |                                                                                         | 205,252                            | 2,458                                         | 1.2            | 42,666                            | 66,279  | 240                                             | 240    | 535                                               | 771    | 5     | 5    | 36.12                        | 52.05    | 0.29  | 0.29  |  |
| <u>Middle Grand River</u>               |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        |                                                   |        |       |      |                              |          |       |       |  |
| a) Grand River above West Montrose      | GA0104                                                                                  | 90,777                             | 3,360                                         | 3.7            | 41,605                            | 41,605  | NIL                                             | NIL    | 1,664                                             | 1,664  | NIL   | NIL  | 112.32                       | 112.32   | NIL   | NIL   |  |
| b) Canagagigue Creek                    | GA0105; GA0106                                                                          | 26,580                             | 1,040                                         | 3.9            | 9,203                             | 9,203   | NIL                                             | NIL    | 368                                               | 368    | NIL   | NIL  | 24.84                        | 24.84    | NIL   | NIL   |  |
| c) Speed River above Guelph             | GA0401; GA0402                                                                          | 68,797                             | 11,187                                        | 16.0           | 25,184                            | 25,184  | 203                                             | 203    | 4,029                                             | 4,029  | 33    | 33   | 271.96                       | 271.96   | 1.88  | 1.88  |  |
| d) Speed River below Guelph             | GA0403; GA0404; GA0405;<br>GA0406; GA0407; GA0408                                       | 56,753                             | 3,507                                         | 6.0            | 11,085                            | 11,085  | 205                                             | 205    | 665                                               | 665    | 12    | 12   | 44.89                        | 44.89    | 0.68  | 0.68  |  |
| e) Eramosa River above Guelph           | GA05                                                                                    | 65,467                             | 1,715                                         | 3.0            | 12,459                            | 12,933  | NIL                                             | NIL    | 374                                               | 388    | NIL   | NIL  | 25.25                        | 26.19    | 0     | 0     |  |
| f) Galt Creek                           | GA0301; GA0302; GA0303;<br>GA0304                                                       | 24,517                             | 160                                           | 0.7            | 3,142                             | 3,142   | NIL                                             | NIL    | 22                                                | 22     | NIL   | NIL  | 1.49                         | 1.49     | 0     | 0     |  |
| g) Grand River above Cambridge          | GA0107; GA0108; GA0109;<br>GA0110                                                       | 125,903                            | Insufficient Data                             |                | 27,627                            | 27,627  | 622                                             | 622    | -                                                 | -      | -     | -    | -                            | -        | -     | -     |  |
| Total                                   |                                                                                         | 458,804                            | 20,978                                        | 4.6            | 130,305                           | 130,779 | 1,030                                           | 1,030  | 7,122                                             | 7,136  | 45    | 45   | 480.75                       | 481.69   | 2.56  | 2.56  |  |
| <u>Paris</u>                            |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        |                                                   |        |       |      |                              |          |       |       |  |
|                                         | GA0111                                                                                  | 23,754                             | 640                                           | 3.0            | 5,997                             | 5,997   | NIL                                             | NIL    | 180                                               | 180    | NIL   | NIL  | 12.15                        | 12.15    | 0     | 0     |  |
| <u>Nith River</u>                       |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        |                                                   |        |       |      |                              |          |       |       |  |
|                                         | GA0201; GA0202; GA0203;<br>GA0204; GA0205; GA0206;<br>GA0207; GA0208; GA0209;<br>GA0210 | 283,104                            | 20,633                                        | 7.3            | 97,993                            | 112,513 | 2,045                                           | 2,045  | 6,855                                             | 7,876  | 143   | 143  | 462.71                       | 531.63   | 8.15  | 8.15  |  |
| <u>Whiteman Creek</u>                   |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        |                                                   |        |       |      |                              |          |       |       |  |
|                                         | GB0501; GB0502                                                                          | 100,662                            | 12,749                                        | 12.7           | 37,178                            | 37,178  | 5,528                                           | 5,528  | 4,461                                             | 4,461  | 442   | 442  | 301.12                       | 301.12   | 25.19 | 25.19 |  |
| <u>Lower Grand River</u>                |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        |                                                   |        |       |      |                              |          |       |       |  |
| a) Fairchild and Big Creek              | GB04; GB03                                                                              | 145,249                            | 973                                           | 0.7            | 38,189                            | 38,189  | 2,040                                           | 2,040  | 267                                               | 267    | 14    | 14   | 18.02                        | 18.02    | 0.80  | 0.80  |  |
| b) McKenzie Creek                       | GB0201                                                                                  | 50,134                             | 2,919                                         | 5.8            | 13,205                            | 13,205  | 2,423                                           | 2,423  | 660                                               | 660    | 121   | 121  | 44.55                        | 44.55    | 6.90  | 6.90  |  |
| c) Boston Creek                         | GB0202                                                                                  | 57,015                             | 1,101                                         | 1.9            | 19,548                            | 24,789  | 1,442                                           | 1,442  | 391                                               | 496    | 29    | 29   | 26.39                        | 33.48    | 1.65  | 1.65  |  |
| d) Grand River below Brantford          | GB0101; GB0102; GB0103                                                                  | 194,826                            | 6,336                                         | 3.3            | 48,733                            | 48,733  | 2,537                                           | 2,537  | 1,462                                             | 1,462  | 51    | 51   | 98.69                        | 98.69    | 2.91  | 2.91  |  |
| Total                                   |                                                                                         | 447,224                            | 11,329                                        | 2.5            | 119,675                           | 124,916 | 8,442                                           | 8,442  | 2,780                                             | 2,885  | 215   | 215  | 197.65                       | 194.74   | 12.26 | 12.26 |  |
| Total Watershed                         |                                                                                         | 1,722,076                          | 73,983                                        | 4.3            | 457,348                           | 515,250 | 17,522                                          | 17,522 | 22,680                                            | 24,424 | 855   | 855  | 1,530.99                     | 1,648.65 | 48.74 | 48.74 |  |

\*Calculated for a 92 day period from June 1 to August 31.



TABLE F1.3  
Estimated Water Demand for Irrigation - Scenario 3

| Sector                                  | Associated Sub-Basins                                                                   | Total Area<br>of Sector<br>(acres) | Estimated Area of Soils<br>In Sand/Sandy Loam |                | Projected Area of<br>Corn (acres) |         | Projected Area of<br>Other Row Crops<br>(acres) |        | Estimated Area<br>Requiring Irrigation<br>(acres) |        |       |      | Estimated Water Demand (mg)* |          |       |       |  |
|-----------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------|-----------------------------------------------|----------------|-----------------------------------|---------|-------------------------------------------------|--------|---------------------------------------------------|--------|-------|------|------------------------------|----------|-------|-------|--|
|                                         |                                                                                         |                                    | Acres                                         | % of Sub Basin | 2001                              | 2031    | 2001                                            | 2031   | Corn                                              |        | Other |      | Corn                         |          | Other |       |  |
|                                         |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        | 2001                                              | 2031   | 2001  | 2031 | 2001                         | 2031     | 2001  | 2031  |  |
|                                         |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        |                                                   |        |       |      |                              |          |       |       |  |
| <u>Upper Grand River</u>                |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        |                                                   |        |       |      |                              |          |       |       |  |
| a) Grand River above Lake Belwood       | GA0101; GA0102                                                                          | 170,178                            | 3,404                                         | 2              | 14,440                            | 25,495  | 237                                             | 237    | 289                                               | 510    | 5     | 5    | 19.51                        | 34.43    | 0.29  | 0.29  |  |
| b) Grand River above Shand Dam          | GA0103                                                                                  | 33,098                             | 1,792                                         | 5              | 9,154                             | 14,756  | NIL                                             | NIL    | 458                                               | 738    | NIL   | NIL  | 30.92                        | 49.82    | NIL   | NIL   |  |
| Total                                   |                                                                                         | 203,276                            | 5,196                                         | 2.6            | 23,594                            | 40,251  | 237                                             | 237    | 747                                               | 1,248  | 5     | 5    | 50.43                        | 84.25    | 0.29  | 0.29  |  |
| <u>Conestogo River</u>                  |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        |                                                   |        |       |      |                              |          |       |       |  |
| a) Conestogo River above Conestogo Lake | GA0601                                                                                  | 68,436                             | 691                                           | 1              | 10,391                            | 18,100  | NIL                                             | NIL    | 104                                               | 181    | NIL   | NIL  | 7.02                         | 12.22    | NIL   | NIL   |  |
| b) Conestogo River above Conestogo Dam  | GA0602                                                                                  | 71,208                             | 666                                           | 1              | 21,430                            | 37,334  | NIL                                             | NIL    | 214                                               | 373    | NIL   | NIL  | 14.45                        | 25.18    | NIL   | NIL   |  |
| c) Conestogo River below Conestogo Dam  | GA0603; GA0604                                                                          | 65,608                             | 1,101                                         | 2              | 27,479                            | 33,350  | 240                                             | 240    | 550                                               | 667    | 5     | 5    | 37.13                        | 45.02    | 0.29  | 0.29  |  |
| Total                                   |                                                                                         | 205,252                            | 2,458                                         | 1.2            | 59,300                            | 88,784  | 240                                             | 240    | 868                                               | 1,221  | 5     | 5    | 58.60                        | 82.42    | 0.29  | 0.29  |  |
| <u>Middle Grand River</u>               |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        |                                                   |        |       |      |                              |          |       |       |  |
| a) Grand River above West Montrose      | GA0104                                                                                  | 90,777                             | 3,360                                         | 3.7            | 36,428                            | 53,152  | NIL                                             | NIL    | 1,457                                             | 2,126  | NIL   | NIL  | 98.35                        | 143.51   | NIL   | NIL   |  |
| b) Canagagigue Creek                    | GA0105; GA0106                                                                          | 26,580                             | 1,049                                         | 3.9            | 7,516                             | 10,628  | NIL                                             | NIL    | 301                                               | 425    | NIL   | NIL  | 20.32                        | 28.69    | NIL   | NIL   |  |
| c) Speed River above Guelph             | GA0401; GA0402                                                                          | 68,797                             | 11,187                                        | 16.0           | 31,453                            | 31,453  | 203                                             | 203    | 5,032                                             | 5,032  | 33    | 33   | 339.66                       | 339.66   | 1.88  | 1.88  |  |
| d) Speed River below Guelph             | GA0403; GA0404; GA0405;<br>GA0406; GA0407; GA0408                                       | 56,753                             | 3,507                                         | 6.0            | 6,788                             | 6,788   | 205                                             | 205    | 407                                               | 407    | 12    | 12   | 27.47                        | 27.47    | 0.68  | 0.68  |  |
| e) Eramosa River above Guelph           | GA05                                                                                    | 65,467                             | 1,715                                         | 3.0            | 12,459                            | 15,929  | NIL                                             | NIL    | 374                                               | 478    | NIL   | NIL  | 25.25                        | 32.27    | NIL   | NIL   |  |
| f) Galt Creek                           | GA0301; GA0302; GA0303;<br>GA0304                                                       | 24,517                             | 160                                           | 0.7            | 3,248                             | 3,248   | NIL                                             | NIL    | 23                                                | 23     | NIL   | NIL  | 1.55                         | 1.55     | NIL   | NIL   |  |
| g) Grand River above Cambridge          | GA0107; GA0108; GA0109;<br>GA0110                                                       | 125,903                            | Insufficient Data                             |                | 21,539                            | 21,539  | 622                                             | 622    | -                                                 | -      | -     | -    | -                            | -        | -     | -     |  |
| Total                                   |                                                                                         | 458,804                            | 20,978                                        | 4.6            | 119,431                           | 142,737 | 1,030                                           | 1,030  | 7,594                                             | 8,491  | 45    | 45   | 512.60                       | 573.15   | 2.56  | 2.56  |  |
| <u>Paris</u>                            | GA0111                                                                                  | 23,754                             | 640                                           | 3.0            | 6,889                             | 6,889   | NIL                                             | NIL    | 207                                               | 207    | NIL   | NIL  | 13.97                        | 13.97    | NIL   | NIL   |  |
| <u>Nith River</u>                       | GA0201; GA0202; GA0203;<br>GA0204; GA0205; GA0206;<br>GA0207; GA0208; GA0209;<br>GA0210 | 283,104                            | 20,633                                        | 7.3            | 93,907                            | 114,077 | 2,045                                           | 2,045  | 6,573                                             | 7,985  | 143   | 143  | 443.68                       | 538.99   | 8.15  | 8.15  |  |
| <u>Whiteman Creek</u>                   | GB0501; GB0502                                                                          | 100,662                            | 12,749                                        | 12.7           | 44,329                            | 44,329  | 5,528                                           | 5,528  | 5,319                                             | 5,319  | 442   | 442  | 359.03                       | 359.03   | 25.19 | 25.19 |  |
| <u>Lower Grand River</u>                |                                                                                         |                                    |                                               |                |                                   |         |                                                 |        |                                                   |        |       |      |                              |          |       |       |  |
| a) Fairchild and Big Creek              | GB04; GB03                                                                              | 145,249                            | 973                                           | 0.7            | 36,304                            | 38,154  | 2,040                                           | 2,040  | 258                                               | 267    | 14    | 14   | 17.42                        | 18.02    | .80   | .80   |  |
| b) McKenzie Creek                       | GB0201                                                                                  | 50,134                             | 2,919                                         | 5.8            | 13,232                            | 14,007  | 2,423                                           | 2,423  | 662                                               | 700    | 121   | 121  | 44.69                        | 47.25    | 6.90  | 6.90  |  |
| c) Boston Creek                         | GB0202                                                                                  | 57,015                             | 1,101                                         | 1.9            | 10,908                            | 15,848  | 1,442                                           | 1,442  | 218                                               | 317    | 29    | 29   | 14.72                        | 21.40    | 1.65  | 1.65  |  |
| d) Grand River below Brantford          | GB0101; GB0102; GB0103                                                                  | 194,826                            | 6,336                                         | 3.3            | 48,824                            | 54,234  | 2,537                                           | 2,537  | 1,465                                             | 1,627  | 51    | 51   | 98.89                        | 109.82   | 2.91  | 2.91  |  |
| Total                                   |                                                                                         | 447,224                            | 11,329                                        | 2.5            | 109,868                           | 122,243 | 8,442                                           | 8,442  | 2,603                                             | 2,911  | 215   | 215  | 175.72                       | 196.49   | 12.26 | 12.26 |  |
| Total Watershed                         |                                                                                         | 1,722,076                          | 73,983                                        | 4.3            | 457,318                           | 559,310 | 17,522                                          | 17,522 | 23,911                                            | 27,382 | 885   | 885  | 1,614.03                     | 1,848.30 | 48.74 | 48.74 |  |

\*Calculated for a 92 day period from June 1 to August 31.

TABLE F1.4  
Estimated Water Demand for Irrigation - Scenario 4

| Sector                                  | Associated Sub-Basins                                                          | Estimated Area Requiring Irrigation |                   |                |                                            |         |                                |        |                                           |        |         |      |        |        |       | Estimated Water Demand (mg)* |       |  |  |
|-----------------------------------------|--------------------------------------------------------------------------------|-------------------------------------|-------------------|----------------|--------------------------------------------|---------|--------------------------------|--------|-------------------------------------------|--------|---------|------|--------|--------|-------|------------------------------|-------|--|--|
|                                         |                                                                                | Total Area of Sector                |                   |                | Estimated Area of Soils In Sand/Sandy Loam |         | Projected Area of Corn (acres) |        | Projected Area of Other Row Crops (acres) |        | (acres) |      |        |        | Corn  |                              | Other |  |  |
|                                         |                                                                                | (acres)                             | Acres             | % of Sub Basin | 2001                                       | 2031    | 2001                           | 2031   | 2001                                      | 2031   | 2001    | 2031 | 2001   | 2031   | 2001  | 2031                         |       |  |  |
|                                         |                                                                                |                                     |                   |                |                                            |         |                                |        |                                           |        |         |      |        |        |       |                              |       |  |  |
| <u>Upper Grand River</u>                |                                                                                |                                     |                   |                |                                            |         |                                |        |                                           |        |         |      |        |        |       |                              |       |  |  |
| a) Grand River above Lake Belwood       | GA0101; GA0102                                                                 | 170,178                             | 3,404             | 2              | 5,940                                      | 5,940   | 237                            | 237    | 119                                       | 119    | 5       | 5    | 8.03   | 8.03   | 0.29  | 0.29                         |       |  |  |
| b) Grand River above Shand Dam          | GA0103                                                                         | 33,098                              | 1,792             | 5              | 4,290                                      | 4,290   | NIL                            | NIL    | 215                                       | 215    | NIL     | NIL  | 14.51  | 14.51  | NIL   | NIL                          |       |  |  |
| Total                                   |                                                                                | 203,276                             | 5,196             | 2.6            | 10,230                                     | 10,230  | 237                            | 237    | 334                                       | 334    | 5       | 5    | 22.54  | 22.54  | 0.29  | 0.29                         |       |  |  |
| <u>Conestogo River</u>                  |                                                                                |                                     |                   |                |                                            |         |                                |        |                                           |        |         |      |        |        |       |                              |       |  |  |
| a) Conestogo River above Conestogo Lake | GA0601                                                                         | 68,436                              | 691               | 1              | 3,530                                      | 3,530   | NIL                            | NIL    | 35.3                                      | 35.3   | NIL     | NIL  | 2.38   | 2.38   | NIL   | NIL                          |       |  |  |
| b) Conestogo River above Conestogo Dam  | GA0602                                                                         | 71,208                              | 666               | 1              | 11,468                                     | 11,468  | NIL                            | NIL    | 115                                       | 115    | NIL     | NIL  | 7.76   | 7.76   | NIL   | NIL                          |       |  |  |
| c) Conestogo River below Conestogo Dam  | GA0603; GA0604                                                                 | 65,608                              | 1,101             | 2              | 14,850                                     | 14,850  | 240                            | 240    | 297                                       | 297    | 5       | 5    | 20.05  | 20.05  | 0.29  | 0.29                         |       |  |  |
| Total                                   |                                                                                | 205,252                             | 2,458             | 1.2            | 29,848                                     | 29,848  | 240                            | 240    | 447.3                                     | 447.3  | 5       | 5    | 30.19  | 30.19  | 0.29  | 0.29                         |       |  |  |
| <u>Middle Grand River</u>               |                                                                                |                                     |                   |                |                                            |         |                                |        |                                           |        |         |      |        |        |       |                              |       |  |  |
| a) Grand River above West Montrose      | GA0104                                                                         | 90,777                              | 3,360             | 3.7            | 16,087                                     | 16,087  | NIL                            | NIL    | 643                                       | 643    | NIL     | NIL  | 43.40  | 43.40  | NIL   | NIL                          |       |  |  |
| b) Canagagigue Creek                    | GA0105; GA0106                                                                 | 26,580                              | 1,049             | 3.9            | 4,854                                      | 4,854   | NIL                            | NIL    | 194                                       | 194    | NIL     | NIL  | 13.10  | 13.10  | NIL   | NIL                          |       |  |  |
| c) Speed River above Guelph             | GA0401; GA0402                                                                 | 68,797                              | 11,187            | 16.0           | 15,381                                     | 15,381  | 203                            | 203    | 2,461                                     | 2,461  | 33      | 33   | 16.12  | 16.12  | 1.88  | 1.88                         |       |  |  |
| d) Speed River below Guelph             | GA0403; GA0404; GA0405; GA0406; GA0407; GA0408                                 | 56,753                              | 3,507             | 6.0            | 6,788                                      | 6,788   | 205                            | 205    | 407                                       | 407    | 12      | 12   | 27.47  | 24.47  | 0.68  | 0.68                         |       |  |  |
| e) Eramosa River above Guelph           | GA05                                                                           | 65,467                              | 1,715             | 3.0            | 3,236                                      | 3,236   | NIL                            | NIL    | 97.5                                      | 97.5   | NIL     | NIL  | 6.55   | 6.55   | NIL   | NIL                          |       |  |  |
| f) Galt Creek                           | GA0301; GA0302; GA0303; GA0304                                                 | 24,517                              | 160               | 0.7            | 1,067                                      | 1,067   | NIL                            | NIL    | 7.5                                       | 7.5    | NIL     | NIL  | .51    | .51    | NIL   | NIL                          |       |  |  |
| g) Grand River above Cambridge          | GA0107; GA0108; GA0109; GA0110                                                 | 125,903                             | Insufficient Data |                | 21,539                                     | 21,539  | 622                            | 622    |                                           |        |         |      |        |        |       |                              |       |  |  |
| Total                                   |                                                                                | 458,804                             | 20,978            | 4.6            | 68,952                                     | 68,952  | 1,030                          | 1,030  | 3,810                                     | 3,810  | 45      | 45   | 34.53  | 34.53  | 2.56  | 2.56                         |       |  |  |
| <u>Paris</u>                            |                                                                                |                                     |                   |                |                                            |         |                                |        |                                           |        |         |      |        |        |       |                              |       |  |  |
|                                         | GA0111                                                                         | 23,754                              | 640               | 3.0            | 5,538                                      | 5,538   | NIL                            | NIL    | 166                                       | 166    | NIL     | NIL  | 11.21  | 11.21  | NIL   | NIL                          |       |  |  |
| <u>Nith River</u>                       |                                                                                |                                     |                   |                |                                            |         |                                |        |                                           |        |         |      |        |        |       |                              |       |  |  |
|                                         | GA0201; GA0202; GA0203; GA0204; GA0205; GA0206; GA0207; GA0208; GA0209; GA0210 | 283,104                             | 20,633            | 7.3            | 64,114                                     | 64,114  | 2,045                          | 2,045  | 4,488                                     | 4,488  | 143     | 143  | 302.94 | 302.94 | 8.15  | 8.15                         |       |  |  |
| <u>Whiteman Creek</u>                   | GB0501; GB0502                                                                 | 100,662                             | 12,749            | 12.7           | 26,231                                     | 26,231  | 5,528                          | 5,528  | 3,148                                     | 3,148  | 442     | 442  | 212.49 | 212.49 | 25.19 | 25.19                        |       |  |  |
| <u>Lower Grand River</u>                |                                                                                |                                     |                   |                |                                            |         |                                |        |                                           |        |         |      |        |        |       |                              |       |  |  |
| a) Fairchild and Big Creek              | GB04; GB03                                                                     | 145,249                             | 973               | 0.7            | 28,232                                     | 28,232  | 2,040                          | 2,040  | 198                                       | 198    | 14      | 14   | 13.37  | 13.37  | .80   | .80                          |       |  |  |
| b) McKenzie Creek                       | GB0201                                                                         | 50,134                              | 2,919             | 5.8            | 7,326                                      | 7,326   | 2,423                          | 2,423  | 366                                       | 366    | 121     | 121  | 24.71  | 24.71  | 6.90  | 6.90                         |       |  |  |
| c) Boston Creek                         | GB0202                                                                         | 57,015                              | 1,101             | 1.9            | 5,854                                      | 5,854   | 1,442                          | 1,442  | 117                                       | 117    | 29      | 29   | 7.90   | 7.90   | 1.65  | 1.65                         |       |  |  |
| d) Grand River below Brantford          | GB0101; GB0102; GB0103                                                         | 194,826                             | 6,336             | 3.3            | 17,730                                     | 17,730  | 2,537                          | 2,537  | 532                                       | 532    | 51      | 51   | 35.91  | 35.91  | 2.91  | 2.91                         |       |  |  |
| Total                                   |                                                                                | 447,224                             | 11,329            | 2.5            | 59,142                                     | 59,142  | 8,442                          | 8,442  | 1,213                                     | 1,213  | 215     | 215  | 81.89  | 81.89  | 12.26 | 12.26                        |       |  |  |
| Total Watershed                         |                                                                                | 1,722,076                           | 73,983            | 4.3            | 264,055                                    | 264,055 | 17,522                         | 17,522 | 13,606                                    | 13,606 | 885     | 885  | 695.79 | 695.79 | 48.74 | 48.74                        |       |  |  |

\*Calculated for a 92 day period from June 1 to August 31.

## APPENDIX G

### LIVESTOCK WATER DEMAND, 1976, 2001 AND 2031

TABLE G1.1

## Livestock Water Demand in the Grand River Watershed (1976)

| Sub-Basin          | No. of Milk Cows | Estimated Water Demand Milk Cows (gpd) | No. of Other Cattle | Estimated Water Demand Other Cattle (gpd) | No. of Pigs | Estimated Water Demand Pigs (gpd) | No. of Sheep | Estimated Water Demand Sheep (gpd) | Total Number of Livestock | Total Estimated Water Demand All Livestock (gpd) |
|--------------------|------------------|----------------------------------------|---------------------|-------------------------------------------|-------------|-----------------------------------|--------------|------------------------------------|---------------------------|--------------------------------------------------|
| Lower Grand River  | 19,725           | 789,000                                | 25,860              | 387,900                                   | 41,681      | 83,362                            | 2,418        | 4,836                              | 89,684                    | 1,265,098                                        |
| Whiteman Creek     | 6,149            | 245,960                                | 10,445              | 156,675                                   | 20,438      | 40,876                            | 145          | 290                                | 37,177                    | 443,801                                          |
| Nith River         | 23,059           | 922,360                                | 52,142              | 782,130                                   | 92,034      | 184,068                           | 1,462        | 2,924                              | 168,697                   | 1,891,482                                        |
| Paris              | 1,002            | 40,080                                 | 3,555               | 53,325                                    | 2,299       | 4,598                             | 167          | 334                                | 7,023                     | 98,337                                           |
| Middle Grand River | 14,421           | 576,840                                | 51,177              | 767,655                                   | 95,463      | 190,926                           | 5,220        | 10,440                             | 166,281                   | 1,545,861                                        |
| Conestogo River    | 19,815           | 792,600                                | 48,437              | 726,555                                   | 121,017     | 242,034                           | 775          | 1,550                              | 190,044                   | 1,762,739                                        |
| Upper Grand River  | 5,803            | 232,120                                | 27,594              | 413,910                                   | 20,755      | 41,510                            | 1,586        | 3,172                              | 55,738                    | 690,712                                          |
| Totals             | 89,974           | 3,598,960                              | 219,210             | 3,288,150                                 | 393,687     | 787,374                           | 11,743       | 23,545                             | 714,644                   | 7,698,030                                        |

TABLE G1.2

## Livestock Water Demand in the Grand River Watershed (2001)

| Sub-Basin          | No. of Milk Cows | Estimated Water Demand Milk Cows (gpd) | No. of Other Cattle | Estimated Water Demand Other Cattle (gpd) | No. of Pigs | Estimated Water Demand Pigs (gpd) | No. of Sheep | Estimated Water Demand Sheep (gpd) | Total Number of Livestock | Total Estimated Water Demand All Livestock (gpd) |
|--------------------|------------------|----------------------------------------|---------------------|-------------------------------------------|-------------|-----------------------------------|--------------|------------------------------------|---------------------------|--------------------------------------------------|
| Lower Grand River  | 5,705            | 228,200                                | 7,480               | 112,200                                   | 12,056      | 24,112                            | 699          | 1,398                              | 25,940                    | 365,910                                          |
| Whiteman Creek     | 6,265            | 250,600                                | 10,642              | 159,630                                   | 20,820      | 41,640                            | 145          | 290                                | 37,872                    | 452,160                                          |
| Nith River         | 32,434           | 1,297,360                              | 73,340              | 1,100,100                                 | 124,440     | 248,880                           | 1,992        | 3,984                              | 232,206                   | 2,650,324                                        |
| Paris              | 1,006            | 40,240                                 | 3,572               | 53,580                                    | 2,520       | 5,040                             | 167          | 334                                | 7,265                     | 99,194                                           |
| Middle Grand River | 26,466           | 1,058,640                              | 93,921              | 1,408,815                                 | 171,975     | 343,950                           | 8,340        | 16,680                             | 300,702                   | 2,828,085                                        |
| Conestogo River    | 22,180           | 887,200                                | 54,218              | 813,270                                   | 139,755     | 279,510                           | 800          | 1,600                              | 216,953                   | 1,981,580                                        |
| Upper Grand River  | 6,301            | 252,040                                | 29,964              | 449,460                                   | 23,651      | 47,302                            | 2,102        | 4,204                              | 62,018                    | 753,006                                          |
| Totals             | 100,357          | 4,014,280                              | 273,137             | 4,097,055                                 | 495,217     | 990,434                           | 14,245       | 28,490                             | 882,956                   | 9,130,259                                        |

TABLE G1.3

## Livestock Water Demand in the Grand River Watershed (2031)

| Sub-Basin          | No. of Milk Cows | Estimated Water Demand Milk Cows (gpd) | No. of Other Cattle | Estimated Water Demand Other Cattle (gpd) | No. of Pigs | Estimated Water Demand Pigs (gpd) | No. of Sheep | Estimated Water Demand Sheep (gpd) | Total Number of Livestock | Total Estimated Water Demand All Livestock (gpd) |
|--------------------|------------------|----------------------------------------|---------------------|-------------------------------------------|-------------|-----------------------------------|--------------|------------------------------------|---------------------------|--------------------------------------------------|
| Lower Grand River  | 5,705            | 228,200                                | 7,480               | 112,200                                   | 12,056      | 24,112                            | 699          | 1,398                              | 25,940                    | 365,910                                          |
| Whiteman Creek     | 4,890            | 195,600                                | 8,306               | 124,590                                   | 16,245      | 32,490                            | 112          | 224                                | 29,553                    | 352,904                                          |
| Nith River         | 39,507           | 1,580,280                              | 89,334              | 1,340,010                                 | 75,795      | 151,590                           | 2,424        | 4,848                              | 207,060                   | 3,076,728                                        |
| Paris              | 907              | 36,280                                 | 3,219               | 48,285                                    | 2,267       | 4,534                             | 157          | 314                                | 6,550                     | 89,413                                           |
| Middle Grand River | 34,787           | 1,391,480                              | 123,451             | 1,851,765                                 | 226,050     | 452,100                           | 10,960       | 21,920                             | 395,248                   | 3,717,265                                        |
| Conestogo River    | 28,729           | 1,149,160                              | 70,228              | 1,053,420                                 | 181,020     | 362,040                           | 1,036        | 2,072                              | 281,013                   | 2,566,692                                        |
| Upper Grand River  | 6,301            | 252,040                                | 29,964              | 449,460                                   | 23,651      | 47,302                            | 2,102        | 4,204                              | 62,018                    | 753,006                                          |
| Totals             | 120,826          | 4,833,040                              | 331,982             | 4,979,730                                 | 537,084     | 1,074,168                         | 17,490       | 34,980                             | 1,007,382                 | 10,921,918                                       |

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